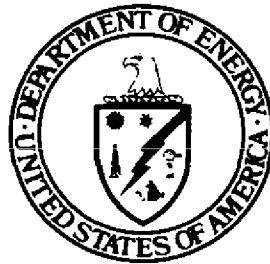


**FINAL
ENVIRONMENTAL IMPACT STATEMENT**

**L-Reactor Operation
Savannah River Plant**

Aiken, S.C.

Volume 1



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U.S. Department of Energy

COVER SHEET

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Abstract: The purpose of this Environmental Impact
Statement (EIS) is to provide environmental
input into the proposed decision to restart
L-Reactor at the Savannah River Plant (SRP).
The Savannah River Plant is a major U.S.
Department of Energy (DOE) installation for
~~the production of nuclear materials for~~ national defense. The L-Reactor operated
from 1954 until 1968, when it was placed in
standby status due to a decreasing demand
for defense nuclear materials. This EIS
assesses the potential environmental effects
of the restart of L-Reactor on air and water
quality, ecological systems, health risk,
archeological resources, endangered species,
and wetlands.

FOREWORD

The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into the proposed decision to restart L-Reactor operation at the Savannah River Plant (SRP). The Savannah River Plant is a major U.S. Department of Energy (DOE) installation for the production of defense nuclear materials. The proposed restart of L-Reactor would provide defense nuclear materials (i.e., plutonium) to meet current and near-term needs for national defense. L-Reactor operated originally from 1954 until 1968, when it was placed in standby status due to a decreasing demand for defense nuclear materials. In March 1981, activities were initiated to renovate and upgrade L-Reactor to the same condition as that of the currently operating SRP Reactors. Renovation and upgrading activities were essentially complete in October 1983.

DOE published an environmental assessment (DOE/EA-0195) on the proposed restart of L-Reactor, and a Finding of No Significant Impact on August 23, 1982 (47 FR 36691). After the publication of the Finding of No Significant Impact in the Federal Register, a number of environmental concerns were raised, and a lawsuit seeking to enjoin the restart of L-Reactor prior to issuance of an environmental impact statement was filed in November 1982.

DOE issued a Floodplain/Wetlands notice regarding the proposed reactivation of L-Reactor on July 14, 1982 (47 FR 30563). A determination regarding no practical alternative was published in the Federal Register on August 23, 1982 (47 FR 36691-2). The Floodplain/Wetlands assessment has been updated and modified in this EIS, and a new determination will be made following completion of the final EIS.

At the request of Senator Strom Thurmond, the Senate Armed Services Committee scheduled a public hearing on February 9, 1983, to provide an opportunity for the public to express their views on the environmental consequences of the proposed restart of the L-Reactor (Senate Hearing 98-18). Subsequently, at the request of Senators Thurmond and Mack Mattingly, the DOE held a 90-day comment period on the Senate hearing record and conducted a series of four additional hearings between May 23 and 27, 1983.

In July 1983, Congress enacted and the President approved the Energy and Water Development Appropriations Act, 1984, which states:

None of the funds appropriated by this Act, or by any other Act, or by any other provision of law shall be available for the purpose of restarting the L-Reactor at the Savannah River Plant, Aiken, South Carolina, until the Department of Energy completes an Environmental Impact Statement pursuant to section 102(2)(C) of the National Environmental Policy Act of 1969 and until issued a discharge permit pursuant to the Federal Water Pollution Control Act (33 U.S.C. 1251, et. seq.) as amended, which permit shall incorporate the terms and conditions provided in the Memorandum of Understanding entered into between the Department of Energy and the State of South Carolina dated April 27, 1983, relating to studies and mitigation programs associated with such restart. For purposes of this paragraph the term "restarting" shall mean any activity related to the operation of the L-Reactor that would achieve criticality, generate fission products

within the reactor, discharge cooling water from nuclear operations directly or indirectly into Steel Creek, or result in cooling system testing discharges which exceed the volume, frequency and duration of test discharges conducted prior to June 28, 1983.

Consistent with the National Environmental Policy Act of 1969, and in consultation with State officials of South Carolina and Georgia, the preparation and completion of the Environmental Impact Statement called for in the preceding paragraph shall be expedited. The Secretary of Energy may reduce the public comment period, except that such period shall not be reduced to less than thirty days, and the Secretary shall provide his Record of Decision, based upon the completed Environmental Impact Statement, not sooner than December 1, 1983, and not later than January 1, 1984.

In response to the November 1982 suit, the Federal District Court of Washington, D.C., in July, also directed DOE to prepare an EIS on the restart of L-Reactor as soon as possible.

A Notice of Intent to prepare this EIS was published in the Federal Register on July 19, 1983 (48 FR 32966). That notice solicited comments and suggestions for consideration in preparing the EIS. The preliminary scope was included in the Notice of Intent; this scope was based on public comments received at the Senate Armed Services Committee hearing held in February 1983 and the 90-day comment period on the record of this hearing.

In response to the Notice of Intent, 42 individuals, organizations, and governmental representatives provided comments to assist in the preparation of the Final EIS. Appendix K provides the issues raised at four scoping meetings and cross references to the appropriate Draft EIS sections. In this Final EIS, Appendix K has been revised to correct typographical errors.

On September 23, 1983, DOE began the public distribution of the Draft EIS to all interested individuals, agencies, and groups for review. On September 28, 1983, a Federal Register Notice (FR 48 44244) announced the availability of the Draft EIS and the conduct of a 45-day review/comment period on the document from October 1 to November 14, 1983. During the comment/review period, DOE conducted four public meetings--in Augusta and Savannah, Georgia, and Aiken and Beaufort, South Carolina.

More than 100 comment letters were received during the 45-day period. Many have led to revisions in this Final Environmental Impact Statement. Appendix M (Volume 3) of this statement contains the comments received during the public comment/review period and DOE's responses to these comments. A copy of the transcripts of the public meetings, public notification procedures used for the public comment/review period, and a copy of all the comments as received during the public review/comment period are contained in the Public Comment/Hearing Report (DOE/SR-5009), which has been placed in local libraries.

In this Final EIS, changes from the draft have been indicated by a vertical line in the margin of each page. Minor typographical and editorial corrections are not identified. Changes that are the result of public comments are identified by the specific comment numbers that appear in Appendix M. A change that is the result of an error (typing error, etc.) in the draft is identified with

the letters "TE," and one made to clarify or expand on the draft statement is identified with the letters "TC." Other changes in this Final EIS are identified by an alphanumeric marginal notation (e.g., AA-1); these notations refer to comments in Appendix M (Volume 3). The responses to these comments also provide additional information and clarification. In this Final EIS, Sections 2.4, 4.4.2, and Appendix I have been extensively revised, and Sections 4.5, 5.1.3, and 5.2.8 and Appendix L have been added to provide a more detailed discussion of cooling-water alternatives and the Department of Energy's preferred alternative. Because of these revisions and additions, no vertical change lines are included for these sections.

The Environmental Assessment (EA) and the Draft EIS contained temperatures for L-Reactor secondary cooling-water discharges and for downstream Steel Creek, based on the reactor operating year-round at 2400 megawatts-thermal. The actual operating power is lower than 2400 megawatts-thermal in the summer and is higher during the other seasons. The operating power is limited by the cooling-water supply temperatures from the Savannah River. The discharge-water temperatures and the resulting temperatures downstream in Steel Creek have been calculated for the actual operating power for each season, and are reflected in this Final EIS.

The estimated remobilization of radioisotopes (primarily cesium-137) in Steel Creek will occur via three mechanisms: (1) desorptive transport, (2) transport in biota, and (3) suspended sediment-water transport. The estimates of the quantities transported via desorption and in biota have remained the same in the EA, the Draft EIS, and this Final EIS (i.e., 1.7 and 0.4 curies, respectively, during the first year). The estimates for the suspended sediment-water transport have been revised. Earlier estimates were based on a 3-day test program and assumed an average concentration of suspended solids and an initial peak transport during the first year. These estimates were 7.7 curies of cesium-137 transported via suspended sediment-water transport during the first year, 7.2 curies transported in the second year, and an annual 20-percent reduction thereafter. The revised estimates are based on a field test program, in which samples were taken at the mouth of Steel Creek during secondary cooling-water system tests over a 53-day period in the spring of 1982; these tests used ambient river water at a flow of about 6 cubic meters per second, which is about half of the full cooling-water flow from L-Reactor. These revised estimates, using the larger data base, are 2.3 curies during both the first and second years, with an annual 20-percent reduction thereafter.

The Savannah River Plant has instituted a program to reduce the amount of process wastewater from the various facilities; the particular emphasis of the program is on reducing discharges to the seepage basins in the Separations (F- and H-) Areas and the Fuel and Target Fabrication (M-) Area. Rearrangements of rinse tanks and procedures, the recycling of evaporator "overhead" water, and other changes in operational procedures have been initiated. In M-Area, for example, the discharge rate to the seepage basin has been reduced since the release of the Draft EIS from 0.85 cubic meter per minute to the present (February 1984) rate of 0.48 cubic meter per minute. By the end of 1984, this discharge is expected to decrease to about 0.05 cubic meter per minute.

Since the preparation of the Draft EIS, the rates of ground-water withdrawn from the Tuscaloosa Aquifer by SRP facilities have changed from those measured

in 1982. In 1983, the sitewide pumping rate was about 27 cubic meters per minute, about 3.2 cubic meters per minute greater than in 1982. This increase is related in part to the increased use in L-Area (from 0.28 to 0.94 cubic meter per minute) and to the increased use in A- and M-Areas (from 5.0 to 6.8 cubic meters per minute); M-Area is producing fuel and targets that could be used in L-Reactor. Ground-water use in F-Area also increased.

More changes in pumping rates are expected in 1984. The M-Area ground-water remedial action project is scheduled to start in August 1984. The effluent from the air stripper will be used to augment the process-water supply used by the A-Area powerhouse; this could reduce A-Area consumption by about 1.1 cubic meters per minute. In September 1984, the F-Area powerhouse will be placed in standby. This will reduce the consumption of ground water from the Tuscaloosa Aquifer by about 1.9 cubic meters per minute.

Considering all factors, DOE has selected a once-through 1000-acre lake as its preferred cooling-water alternative. The impacts of this alternative were bracketed in the Draft EIS by the 500-acre and 1300-acre cooling ponds.

This EIS was prepared in accordance with the Council on Environmental Quality NEPA regulations (40 CFR 1500-1508) and DOE's NEPA guidelines (45 FR 20694, March 28, 1980) by DOE and by DOE's contractors under the direction of DOE. Methodologies used and scientific and other sources of information relied upon for conclusions are explicitly identified in this EIS; it is based on comprehensive environmental information drawn from over 100 publicly available documents developed over the last 30 years. In addition, available results of ongoing studies have been used.

The discussion on the need for L-Reactor is, by necessity, qualitative in nature because quantitative information on defense material requirements and production capacity is classified; detailed quantitative discussion on need is contained in a classified appendix, Appendix A. This appendix is not available for public review.

Referenced material in the EIS has been reviewed for classification and sensitivity and is available for review in the U.S. Department of Energy Public Reading Rooms: 211 York Street, N.E., Aiken, SC 29801, and 1000 Independence Ave, S.W., Washington, DC, between the hours of 8:30 a.m. and 4:30 p.m., Monday through Friday.

SUMMARY

This section summarizes the Final Environmental Impact Statement (EIS) on the proposed restart of L-Reactor at the Savannah River Plant (SRP) in South Carolina. In preparing this Final EIS, the U.S. Department of Energy (DOE) has considered the comments that were submitted by government agencies, private organizations, and individuals during the public review period that followed publication of the Draft EIS in September 1983.

This summary also presents the principal comments on the Draft EIS grouped by category, the Department's responses, and modifications made in response to these comments. Also, as required by the Council on Environmental Quality's (CEQ) regulations for implementing the procedural provisions of the National Environmental Policy Act (NEPA), the Final EIS discusses the Department's preferred alternative.

Contents of the EIS

In accordance with the provisions of the National Environmental Policy Act and the Department of Energy's NEPA guidelines, the Final EIS contains a description of the proposed action, which is the restart of L-Reactor as soon as practicable, and the reason for this action. The Final EIS also contains descriptions of the following major elements:

- Alternative ways to produce defense nuclear materials
- The present environment that would be affected by the restart of L-Reactor
- The environmental consequences of L-Reactor operation
- Potential ways to reduce the environmental effects of restarting L-Reactor
- The environmental effects that would arise from the increased use of existing SRP facilities due to L-Reactor restart, and the cumulative environmental effects
- Environmental monitoring and studies
- Federal and state requirements for the restart of L-Reactor, and the status of compliance with these requirements

Purpose of this EIS

The Department of Energy, as a Federal agency, is required by the National Environmental Policy Act of 1969, as amended, to assess the potential environmental impacts of its major actions. In August 1982 the Department, seeking to comply with NEPA requirements, published an Environmental Assessment on the restart of L-Reactor and a related Finding of No Significant Impact. Following publication of this finding, a number of groups and individuals expressed their concerns about the possible environmental effects of the L-Reactor restart.

Subsequently, in November 1982, a lawsuit was filed seeking to prevent the restart of L-Reactor until an environmental impact statement had been prepared.

On July 14, 1983, the President signed the Energy and Water Development Appropriations Act, 1984, which directed the Department of Energy to prepare an EIS on L-Reactor on an "expedited" basis. On July 15, 1983, the Federal District Court of Washington, D.C., acting on the November 1982 lawsuit, directed the Department of Energy to prepare an EIS on the proposed restart of L-Reactor. Accordingly, on July 19, 1983, the Department announced that it would prepare an EIS on the proposed restart of L-Reactor to comply with the provisions of NEPA and the Energy and Water Development Appropriations Act, 1984.

The purpose of this EIS is to assess the environmental consequences of the proposed restart of L-Reactor. This Final EIS sets forth and evaluates two major kinds of activities: The first are potential ways to produce defense nuclear materials as alternatives to the restart of L-Reactor; the second are mitigation measures that could avoid, reduce, or compensate for environmental effects occurring before or after the restart. Congressional approval might be necessary for certain alternatives to the restart and for some mitigation measures.

Based on this Final EIS, the Department will prepare a Record of Decision that will state the Department's decision on the proposed restart of L-Reactor. The Record of Decision will identify all the alternatives considered, including those considered environmentally preferable, and will review the factors that were weighed in balancing the need for the restart of L-Reactor against the potential environmental effects from its operation.

Proposed Action

Under the Atomic Energy Act of 1954, the Department of Energy is responsible for developing and maintaining the capability to produce all defense nuclear materials required for the U.S. weapons programs. To this end, the Department operates nuclear reactor production complexes at its Hanford Reservation and Savannah River Plant. The Hanford Reservation currently operates a single reactor, the N-Reactor, for both nuclear materials and steam production; the Savannah River Plant operates three reactors--C-, K-, and P-Reactors--to produce defense nuclear materials only.

The proposed action in this EIS is to restart L-Reactor as soon as practicable. L-Reactor, which is located on the Savannah River Plant, previously operated from 1955 to 1968 to produce plutonium. It is a heavy-water (deuterium oxide) moderated, special-purpose production reactor. Its secondary cooling water is supplied from the Savannah River.

The Department's preferred alternative in this Final EIS is to restart L-Reactor after the construction of a 1000-acre once-through cooling lake. This preferred alternative is different from that presented in the Draft EIS, which was the restart of L-Reactor with direct discharge of secondary cooling water to Steel Creek followed by subsequent thermal mitigation. The impacts of the 1000-acre lake were fully bracketed by the discussions in the Draft EIS of the 1300- and 500-acre impoundments. The actual acreage has been changed but the identification and nature of the impacts is essentially the same. Direct

discharge is referred to as the "reference case" alternative in this Final EIS. The change in the preferred alternative was made in response to public comments and a determination by the State of South Carolina that direct discharge would not be permittable under the current National Pollutant Discharge Elimination System (NPDES) permit regulations.

To ensure that the preferred cooling-water alternative is a viable option for the decisionmaker consistent with the restart of L-Reactor as soon as practicable, the Department prepared and filed dredge and fill (404) and NPDES permit applications with the U.S. Army Corps of Engineers and the South Carolina Department of Health and Environmental Control (SCDHEC), respectively, before the completion of this Final EIS.

Need for L-Reactor

To meet the additional requirements for plutonium contained in the Nuclear Weapons Stockpile Memorandum approved by President Carter on October 24, 1980, the Department of Energy proceeded to implement the most timely and cost-effective production initiatives. These initiatives provided a substantially greater amount of plutonium but not enough to fully meet the requirements. Accordingly, the Department proposed several additional initiatives for implementation, including the restart of L-Reactor at the Savannah River Plant.

The requirements for increased defense nuclear material and the production initiatives necessary to provide the additional production capacity have been reaffirmed in subsequent Stockpile Memoranda since 1980, including a Memorandum for fiscal years 1984 through 1989 that was approved by President Reagan on February 16, 1984. This Nuclear Weapons Stockpile Memorandum--which is the most recent--defines the annual requirements for defense nuclear materials for fiscal years 1984 through 1989, the planning directives for the next 5-year period, and 5 additional years of projections for long-range planning.

In approving the Stockpile Memorandum, President Reagan emphasized the importance of meeting annual requirements and maintaining an adequate supply of defense nuclear materials by directing that: "As a matter of policy, national security requirements shall be the limiting factor in the nuclear force structure. Arbitrary constraints on nuclear materials availability shall not be allowed to jeopardize attainment of the forces required to assure our defense and maintain deterrence. Accordingly, DOE shall . . . assure the capability to meet current and projected needs for nuclear materials and . . . restart the L-Reactor at the Savannah River Plant, Aiken, S.C., as soon as possible."

The specific need for L-Reactor is supported by a quantitative analysis of the production capabilities of DOE facilities and the requirements set forth in the Nuclear Weapons Stockpile Memorandum. This information is classified in accordance with the Atomic Energy Act of 1954. A classified appendix to this EIS (Appendix A), which contains the quantitative analysis of the need for L-Reactor, has been revised in accordance with the latest approved Nuclear Weapons Stockpile Memorandum. This analysis supports the need to restart L-Reactor as soon as practicable.

During the public review period on the Draft EIS, comments were submitted on the need for additional defense nuclear materials and the quantitative analysis supporting this need. Based on these comments, the Department has provided

additional information in Chapter 1 to clarify the production capabilities of selected production initiatives. The Department has not, however, modified this Final EIS to include an analysis of the need for nuclear weapons, their use, and specific nuclear weapon systems, or to include a publicly available quantitative analysis of the need for defense nuclear materials. Information on defense nuclear material requirements, inventories, production capacity, and projected effects on weapon system deployments is classified. In addition, the national policy on nuclear weapons, their deployment, and the need for increased weapons is beyond the scope of this EIS.

Production Alternatives to the Restart of L-Reactor

In accordance with NEPA regulations, the Department of Energy has examined a range of production alternatives to the restart of L-Reactor as soon as practicable. The alternatives include those that have production capabilities similar to that of L-Reactor and those that have only partial-production capabilities compared with that of L-Reactor.

The alternatives that have production capabilities that are similar to that of L-Reactor include restarting R-Reactor at the Savannah River Plant; restarting one of the K-Reactors at the Hanford Reservation in Richland, Washington; and recovering plutonium from spent fuel produced by commercial power reactors.

R-Reactor began operation in late 1953 and was placed in standby status in mid-1964 due to a decline in the need for defense nuclear materials. Since R-Reactor was placed in standby status, its systems and components have not been maintained as well as those in L-Reactor and could not be started in less than 5 years. K-West (KW) and K-East (KE) Reactors at the Hanford Reservation began operation in 1955 and were shut down in 1970 and 1971, respectively, due to a decline in the need for defense nuclear materials. The K-Reactors have been retired and are being prepared for decontamination and decommissioning. The fuel fabrication plant has been dismantled and some essential equipment has been removed. More than 5 years would be required to restore either K-Reactor for the production of plutonium.

Theoretically, weapon materials could be produced directly in existing commercial light-water reactors, or weapons-grade plutonium could be separated isotopically from high-assay plutonium in existing spent fuel from light-water reactors. However, the conversion of spent commercial reactor fuel into weapons-grade plutonium is currently prohibited by law [Atomic Energy Act of 1954, as amended, 42 USC section 2007(e)].

The alternatives that have partial-production capabilities compared to that of L-Reactor are as follows: increasing the power of the N-Reactor at the Hanford Reservation or increasing the power of operating reactors at the Savannah River Plant; reducing the plutonium-240 content of reactor-produced plutonium to allow a more rapid conversion of fuel-grade plutonium into weapons-grade material through blending; and adopting (sooner than had been scheduled) a new design for plutonium-producing fuel assemblies--known technically as the Mark-15 fuel lattice--in the SRP reactors. A quantitative analysis has shown that none of these options, or combinations of options, would provide the required amount of defense nuclear materials.

The Department has also examined a delayed L-Reactor restart in combination with the implementation of two partial-production options--the accelerated use of the Mark-15 lattice in the SRP reactors and the reduction of the plutonium-240 content of plutonium produced in N-Reactor. The Department's analysis concluded that implementing these partial-production options would require additional time and Congressional action to appropriate funds for the use of the Mark-15 lattice, which also would require more time. Furthermore, this combination of alternatives would not provide the amount of required defense nuclear materials.

As required by NEPA, the Department also considered taking no action and maintaining the L-Reactor in a ready-for-operation mode. However, no action would not meet the requirements for defense nuclear materials.

The only available production alternative that satisfies the requirements for defense nuclear materials is the restart of L-Reactor as soon as practicable.

Individuals who commented on the Draft EIS suggested accelerating several partial- and full-production initiatives, including the development of a new production reactor, the recovery of material from retired and obsolete warheads, and an accounting of any surplus production material. None of these accelerated initiatives could provide the required material in sufficient time. The recovery of material from retired and obsolete warheads as well as from production material surpluses was taken into account in the need for material contained in the Nuclear Weapons Stockpile Memoranda. After careful review of the comments, the Department did not make any major changes to the discussion of production alternatives in this Final EIS.

Environmental Effects of the Restart of L-Reactor

This Final EIS first discusses the environmental effects of the restart of L-Reactor without the implementation of any mitigation measures (i.e., the reference case). Reasonable mitigation measures that could reduce environmental impacts are then discussed, followed by the environmental consequences of the Department's preferred alternative and those of no action.

The following sections summarize the environmental impacts of the Department's preferred alternative, including the impacts of normal operation, incremental impacts, cumulative impacts, and potential impacts from postulated accidents.

Normal operation. The Department of Energy's preferred alternative is to restart L-Reactor as soon as practicable, together with the following actions:

- Construct a 1000-acre lake before resuming L-Reactor operation, redesign the reactor outfall that carries the thermal discharge from the reactor to the lake, and operate L-Reactor in such a way that a temperature of 90°F (32.2°C) or less is maintained in about half the lake, thereby ensuring a balanced biological community. After L-Reactor is operating, the Department will conduct studies to confirm the effectiveness of the cooling lake and to decide on the need for precooling devices to allow greater operational flexibility.

- Use the L-Area seepage basin for the periodic disposal of disassembly-basin purge water, while continuing to study and evaluate moderator detritiation.
- Use batch discharge for the periodic disposal of sludge from the L-Reactor cooling-water reservoir.
- Use the existing L-Reactor confinement system.

The principal environmental effects of the preferred alternative would be the results of the construction and use of the 1000-acre lake to reduce L-Reactor thermal effects, the withdrawal of cooling water from the Savannah River, and the release of radionuclides.

Cooling lake--The 1000-acre lake would be constructed by placing an embankment across Steek Creek upstream from the Seaboard Coast Line Railroad bridge. The lake would be about 3900 feet (1200 meters) at its maximum width--with an average width of approximately 2000 feet (600 meters)--and would extend about 4 and a half miles (7 kilometers) upstream from the embankment. While the embankment was being built, the creek would flow past the work area through a temporary metal conduit. The construction of the lake would also require the relocation of electric transmission and cable rights-of-way.

Under an expedited schedule, the 1000-acre lake could be complete in 6 months at a capital cost of approximately \$25 million. This major acceleration of the schedule has been made possible because of the Corps of Engineers workforce recently utilized for the construction of the Richard B. Russell Dam on Savannah River is now becoming available and because no long-lead-time equipment items are required for this alternative. Approximately 550 construction personnel, including civil engineers for design and supervision, would be required to construct the lake.

The lake would inundate 225 acres of wetlands and 775 acres of uplands in the Steel Creek corridor. An additional 100 acres of uplands would be lost due to the relocation of electric and cable rights-of-way. A total of between 735 to 1015 acres of wetlands in the Steel Creek corridor, delta, and Savannah River swamp would be impacted.

One historic mill-and-dam site that is eligible for inclusion in the National Register of Historic Places would also be inundated. A resource recovery plan for this site has been developed by the University of South Carolina Institute of Archeology and Anthropology and has been approved by the State Historic Preservation Officer and the Advisory Council on Historic Preservation. Additional historic and archeological sites might be located in the lake area. A survey is underway to identify potentially significant sites. Contingent on the survey's results, needed measures would be taken before the lake is filled.

Construction of the earthen embankment and diversion system would cause some temporary increases in suspended solids in Steel Creek. Fugitive dust and particulate emissions from construction and clearing activities would occur. These emissions, though, would be confined to relatively small areas and would be generally short-lived. Runoff and sediment from construction areas would be controlled by the use of sediment basins and other control measures such as berms, dikes, drains, and mulch.

When the construction of the lake has been completed and the lake filled, L-Reactor thermal discharges would enter through a modified discharge structure that would enhance cooling efficiency. Cooling-water discharges would be managed by altering reactor power levels to maintain a balanced biological community in the lake [i.e., about 50 percent of the lake would not exceed 90°F (32.2°C)]. The balanced biological community probably would not be established until 3 to 5 years after the lake had been filled. The projected water temperatures in the summer (5-day worst case) at the Steel Creek delta and mouth would be within 2°F (1°C) above the ambient temperature. During the winter, projected temperatures at Road A and points downstream from the embankment would be from 13° to 16°F (7°C to 9°C) above the ambient temperature. The lake concept and the management of L-Reactor discharges are expected to meet State water-quality standards.

The Department of Energy anticipates that the lake would contain a balanced biological community similar to that of Par Pond on the Savannah River Plant. Fish species from the Savannah River could enter the lake as eggs, larvae, or fry when L-Reactor is not operating. The exact balance of species that will develop cannot be predicted accurately; however, experience at Par Pond indicates that a community dominated by bass and bluegill would probably develop.

Endangered species--The flows of water from the lake during periods of L-Reactor operation would affect foraging habitat for the endangered wood stork and habitat for the American alligator.

The wood stork (Mycteria americana) was listed as an endangered species on February 28, 1984--five months after the Draft EIS for L-Reactor was completed. Studies on the wood stork were initiated in April 1983. The design of the study program together with its preliminary results were reviewed with the U.S. Fish and Wildlife Service (FWS) during an informal consultation process. Data from the wood stork program is contained in this Final EIS. A Biological Assessment of the wood stork was submitted to the FWS at the end of March 1984. The FWS is reviewing this assessment before it issues its Biological Opinion, which could include mitigation measures. The Department anticipates that after its review, the FWS will concur in the Department's conclusion that while the operation of L-Reactor could affect portions of the wood stork's SRP foraging habitat, the operation of L-Reactor and of other ongoing and planned operations would not affect the continued existence of this species.

On February 25, 1983, the FWS issued a Biological Opinion on the American alligator (Alligator mississippiensis), which concluded that the operation of L-Reactor as then proposed--direct discharge of cooling water--would not jeopardize the continued existence of this species. Since the Biological Opinion was issued, the Department has identified the 1000-acre lake as its preferred cooling-water system. An updated biological assessment that includes the 1000-acre lake was submitted to the FWS at the end of March 1984. The FWS is reviewing this updated assessment before it issues a Biological Opinion, which could include needed mitigation measures. The Department anticipates that, after its review, the FWS will concur with the Department's finding that L-Reactor operation would not have an adverse effect on the continued existence of this species.

The Department is cooperating with the Fish and Wildlife Service to develop a Habitat Evaluation Procedure (HEP) for the Steel Creek system and the 1000-acre lake. The HEP will identify the value of habitat to be gained or lost with the implementation of the preferred cooling-water alternative for use in assessing further mitigation. The Department will implement additional mitigative measures that might be identified through the HEP process; if required, it will request Congressional funding authorization and appropriation.

Cooling-water withdrawal--During L-Reactor operation, water for secondary cooling would be withdrawn from the Savannah River at a rate of about 400 cubic feet (11 cubic meters) per second. This withdrawal--amounting to less than 4 percent of the average flow and 7 percent of the 7-day, 10-year low flow of the river--would cause entrainment and impingement of fish, fish eggs, and larvae in the area of the water intake canal. Studies in 1982 and 1983 show that an estimated 3 to 6 percent of the fish eggs and larvae that pass the intake canal would be lost annually. An estimated average of 16 fish per day would be lost due to impingement during normal river flow.

Radioactive releases--The discharge of L-Reactor cooling water would transport a portion of the cesium-137 and cobalt-60 that remains in the Steel Creek channel and floodplain. The quantities of cesium-137 and cobalt-60 that would be transported from Steel Creek to the Savannah River and to the offsite Creek Plantation Swamp were estimated by monitoring their movement in Steel Creek at flows as high as 220 cubic feet (6 cubic meters) per second during cold flow testing of L-Reactor.

Because the factors that could influence such transport in the combined lake-stream system are difficult to quantify precisely, it is conservatively estimated to be no greater than that from direct discharge (i.e., 4.4 curies of cesium-137 and 0.25 curie of cobalt-60 during the first year).

In addition to the radiocesium and radiocobalt transported to the Savannah River and the adjacent swamp, other liquid and atmospheric releases of radioactivity would occur during normal operation of L-Reactor. The principal sources of these releases are the disassembly basin for irradiated fuel and target assemblies in the reactor building and the periodic purge of water from this basin to the L-Area seepage basin. Radioactivity would be released as a result of the evaporation of water containing tritium in the seepage basin, and as a result of the movement of radionuclides from the seepage basin through shallow ground water to the 1000-acre lake. This movement through the shallow ground water would allow partial decay of the radioactivity. The discharge to the seepage basin would be expected to affect only shallow ground water in the vicinity of L-Reactor; deeper ground-water formations such as the Tuscaloosa and Congaree would not be affected by radioactivity because of the geologic and hydrologic characteristics of the L-Reactor area.

Other sources of radioactivity include atmospheric effluents generated during reactor operation and releases of small process-water leaks into the cooling-water discharge.

The conservatively estimated radiological dose to the maximally exposed person living near the Savannah River Plant from all L-Reactor sources during the first year of normal operation would be 3.6 millirem, or 1/26 of that received from natural radiation sources during the same year. The average dose to

the population within 50 miles (80 kilometers) of the Plant and to the Beaufort-Jasper and Port Wentworth water-consuming populations during that year would be 27.6 person-rem, or 1/3900 of the dose from natural background radiation.

Comments--Many of the comments on the Draft EIS were related to the direct discharge of cooling water, the environmental effects of such discharge, and the potential impact on ground water from the periodic discharge of disassembly-basin water to the L-Area seepage basin.

Comments on the discharge of cooling water dealt principally with how the direct discharge of cooling water related to the water-quality standards of the State of South Carolina. In the Draft EIS, direct discharge was examined in relation to conditions contained in the National Pollutant Discharge Elimination System (NPDES) draft permit issued by the State in August 1982. Several comments noted that subsequent drafts of the permit contained a different compliance point--from in the Savannah River to the discharge point at Steel Creek. Therefore, the direct discharge of cooling water could not comply with the State's standards.

As a result of these comments and continuing discussions with the State of South Carolina on an NPDES permit for L-Reactor, the Department has modified Section 4.1 of this Final EIS by dropping the analysis of direct discharge as it related to the NPDES draft permit issued in August 1982. In addition, Section 4.4.2, which describes cooling-water mitigation measures, includes more measures than those described in the Draft EIS and provides temperature data for assessing compliance with water-quality standards. Also, the Department has changed its preferred cooling-water alternative from direct discharge and subsequent mitigation to construction of a 1000-acre lake prior to L-Reactor restart. Several new sections have been added to discuss this preferred alternative specifically.

Some comments also questioned the analysis of potential ground-water impacts from the periodic discharge of radioactively contaminated disassembly-basin purge water to the L-Area seepage basin. Specifically, these comments questioned the basis for predicting a horizontal movement of radionuclides through shallow ground water rather than vertical movement into deeper, more important ground-water formations, and the effect on future ground-water use of the movement of radionuclides. To clarify the bases for its predictions of horizontal movement and the effect of additional ground-water use, the Department has included additional information in Chapters 3 and 4 and Appendix F.

In response to other comments, the Department has incorporated additional information in the Final EIS on continuing studies of the wood stork and on entrainment and impingement.

Incremental impacts. The restart of L-Reactor would result in incremental increases in the level of effluents and emissions and handling of materials at a number of facilities currently operating at the Savannah River Plant. These facilities include a fuel and target fabrication area (M-Area), two chemical separations areas for irradiated materials (F- and H-Area), and facilities that generate steam and handle and store high- and low-level radioactive waste.

The main environmental effects from incremental increases at these operating facilities would result from greater discharges to the seepage basins in

the M-, F-, and H-Areas, and incremental increases in both ground-water withdrawal and radioactive releases.

Discharges to seepage basins--The M-Area seepage basin was placed in service in 1958 to settle out and contain uranium discharges from fuel and target production operations. Currently, very little wastewater seeps from the basin; instead, most of the water overflows the basin and seeps into the ground at Lost Lake. In the past, waste effluents included large volumes of volatile organic compounds used as metal degreasing agents. Substantial quantities of these solvents entered shallow ground water from several sources: effluent sewer leaks, the seepage basin, overflow to Lost Lake, and miscellaneous spills. In early 1982, the State of South Carolina and EPA were promptly notified that concentrations of two organic degreasers--no longer used at SRP--were detected in the Tuscaloosa Formation. On the basis of well surveys and monitoring, the contamination of the Tuscaloosa Formation is believed to have resulted from the movement of organic degreasers from shallow ground water down the annuli of wells that had defective cement grout between the sediment and the well casings.

The discharge of volatile organic compounds in process wastewaters from the M-Area operations has been reduced substantially due to recent changes in operating practices. The use of one sewer line to the M-Area seepage basin has been discontinued and another line has been repaired.

High concentrations of the organic compounds in the shallow ground water in the M-Area are being removed by both a pilot and a prototype air stripper. State and Federal agencies have reviewed the ground-water remedial action plan for the removal of the organic compounds using recovery wells and a large air stripper; this plan will be implemented in August 1984. The use of the M-Area seepage basin is scheduled to be discontinued by April 1985, when a new wastewater-treatment plant will begin processing the effluent.

Fuel and targets for loading into the L-Reactor already have been produced in the M-Area. The incremental increase in the discharge to the M-Area seepage basin due to L-Reactor represents approximately a 33-percent increase. However, by the end of 1984, the effluent volume attributable to L-Reactor incremental increases will be reduced by 80 percent. Contaminants discharged to the M-Area seepage basin due to L-Reactor and previous SRP operations prior to April 1985 are expected to be intercepted by the wells to be installed as part of the remedial action program. After April 1985, any incremental releases attributable to L-Reactor will be treated by a new wastewater treatment facility.

Since 1954 and 1955, the Savannah River Plant has discharged large volumes of nonradioactive chemicals and low levels of radioactivity to the seepage basins in the F- and H-Areas. The present discharges to the F- and H-Area seepage basins are not characterized as "hazardous" except for frequent periods of low pH and infrequent discharges of mercury and chromium. The chromium discharges result primarily from the processing of offsite fuels. Discharges to the F- and H-Area seepage basins have not resulted in contamination of the Congaree ground water or of ground water in deeper formations such as the Tuscaloosa. The green clay--a thick layer at the base of the McBean Formation--and the clays in the upper Ellenton Formation and at the base of the Congaree Formation have been effective barriers in preventing the vertical movement of contaminants in the F- and H-Areas.

Because of changes in operating practices--principally recycling--discharges to the F- and M-Area seepage basins have been reduced since 1982 by 45 percent and 7 percent, respectively.

The Department of Energy plans to request fiscal year 1986 Congressional funding for an effluent treatment facility to process the wastewater discharged to the F- and H-Area seepage basins.

Ground-water withdrawal--The L-Reactor restart would result in the withdrawal of additional ground water for operating facilities. The additional withdrawal is projected to be about 210 cubic feet (5.9 cubic meters) per minute, which would be a 7-percent increase over the withdrawal rate at SRP in 1982. This withdrawal is expected to have little impact on offsite water levels; however, increased withdrawals could cause the head differential between the Tuscaloosa and Congaree in the H-Area to become downward, and the head differential in the M-Area to become increasingly downward. These changes to the head differential are not expected to result in any contamination of aquifers such as the Tuscaloosa because of the presence of the green clay in the central portion of the Plant and the establishment of the remedial action program for the M-Area.

Ground-water protection--The Department of Energy is currently committed to several items related to ground-water monitoring and mitigation at the Savannah River Plant, including:

- Continuing and expanding the program of ground-water monitoring and studies
- Involving the State of South Carolina in onsite ground-water monitoring activities
- Taking mitigative actions to reduce pollutants released to the ground water and establishing a mutually agreed-on compliance schedule for mitigation efforts

A number of comments concern the contamination of ground water at SRP, especially from such practices as the use of seepage basins. The Department has drafted an "SRP Groundwater Protection Implementation Plan," which examines strategies and schedules for initiating mitigative actions for the cleanup of past operations that threaten to or contaminate SRP ground water, including the closing and decommissioning of seepage basins. The plan has been reviewed by State agencies and the Environmental Protection Agency. The mitigation actions ultimately adopted will be the subject of a separate NEPA review.

Radioactive releases--The resumption of L-reactor operation would also result in incremental radioactive releases from the Central Shops area, the fuel and target fabrication area, and the separations area. These incremental releases would result in a composite maximum individual dose of 0.087 millirem in the first year and 0.072 millirem during the tenth year, or less than 0.1 percent of the average dose of 93 millirem received by an individual living near the SRP site from natural sources of radiation. The maximum population dose from incremental releases is estimated to be 8.1 person-rem in the tenth year of L-Reactor operation, or about 0.007 percent of the dose to the population living

within 50 miles (80 kilometers) of the Plant and the Beaufort-Jasper and Port Wentworth drinking-water populations from natural radiation sources.

This Final EIS also discusses the potential impacts associated with incremental increases in the handling and storage of high- and low-level radioactive waste.

Comments--Comments on the Draft EIS regarding incremental impacts from the restart of L-Reactor were concerned primarily with the potential ground-water impacts from continued seepage basin use. Comments ranged from general statements that the restart of L-Reactor would increase ground-water contamination by 33 percent to several specific comments on ground-water data, analysis methodologies, and assumptions about geology and hydrology.

Comments from state and Federal agencies indicated concern about jurisdictional responsibilities under the Resource Conservation and Recovery Act, and the relationship of proposed cleanup programs to incremental increases in releases due to the restart of L-Reactor. Almost all the comments received reflected a general concern that the restart of L-Reactor should not increase any existing levels of ground-water contamination.

The Department has made several modifications in this Final EIS in response to the comments received. These include the addition of well data and recent monitoring results, additional analyses on the amount of incremental releases to seepage basins, the effects of additional ground-water withdrawal, and additional information on the present status of remedial action and ground-water protection programs.

Cumulative impacts. The cumulative impacts considered in the EIS include the effects of L-Reactor and support facility operations together with those of other SRP and major nearby facilities. Major SRP facilities include the planned Fuels Material Facility and Defense Waste Processing Facility. Other facilities near the SRP include the Vogtle Nuclear Power Plant, the Urquhart Steam Station, the Chem-Nuclear, Inc., plant, and the Barnwell Nuclear Fuel Plant.

The primary areas of cumulative environmental impact discussed in this Final EIS include socioeconomic impacts and the impacts from ground-water usage, cooling-water withdrawal and discharge, and radioactive releases.

Socioeconomics--Construction of the Fuel Materials Facilities, the Defense Waste Processing Facility, and other Savannah River Plant projects are expected to increase the labor force by 2800 persons by the end of September 1984. In addition, the restart of the L-Reactor would temporarily add about 550 personnel to construct the 1000-acre lake. The cumulative work force that might relocate to the area would total about 800 personnel. This work force, some of which has already relocated, is not expected to cause major impacts in the six-county area surrounding SRP.

Ground-water use--Cumulative ground-water consumption at the Savannah River Plant is expected to increase slightly--30 cubic feet (0.75 cubic meter) per minute--because of the operation of the Fuel Materials Facility and the Defense Waste Processing Facility. The added withdrawals will reduce the upward head differential between the Tuscaloosa and Congaree Formations in the central portion of the Savannah River Plant, and the head differential will become

increasingly downward beneath the H- and M-Areas. These changes in the head differential will not affect the quality of ground water in the Tuscaloosa Aquifer because of clay barriers at the F- and H-Areas and the remedial action program at the M-Area. The cumulative SRP ground-water withdrawal impacts on off-site water levels are expected to be small.

Cooling-water discharge and withdrawal--In addition to the proposed restart of L-Reactor, other sources of thermal discharge include the currently operating reactors at the Savannah River Plant, the Vogtle Nuclear Power Plant, which will use natural-draft cooling towers, and the Urquhart Steam Station. Cumulative thermal discharges to Steel Creek from the proposed 1000-acre lake and K-Reactor are expected to be less than 7°F (4°C) above the water temperature of the Savannah River during spring and summer at the mouth of Steel Creek. No thermal blockage is expected in the Savannah River as a result of SRP and Vogtle Power Plant thermal discharges. The total cumulative withdrawal from the Savannah River for cooling water is expected to result in the entrainment of about 19 percent of the fish eggs and larvae passing the Plant intakes and the impingement of about 53 fish per day. During periods of high water, cumulative impingement could reach 104 fish per day.

Radioactive releases--The cumulative SRP radiological effects analyzed in this Final EIS include the sum of the doses from L-Reactor, its increment of the support facilities, current operation with three reactors, and the planned Fuel Materials Facility and Defense Waste Processing Facility--which are expected to become operational in the late 1980s. The radiological dose due to the Vogtle Nuclear Power Plant was included, but the dose from the Barnwell Nuclear Fuel Plant was not included because this plant is not expected to operate. The cumulative composite maximum individual dose of 3.6 millirem is 27 times less than the average dose of 93 millirem received by an individual living near the site from natural radiation. The cumulative composite population dose of 163 person-rem is about 0.15 percent of the exposure of about 109,000 person-rem from natural radiation sources to the population living within 50 miles (80 kilometers) of the Savannah River Plant and the Beaufort-Jasper and Port Wentworth drinking-water populations.

Comments--Comments on the Draft EIS cumulative impact discussion included requests that the Department (1) evaluate the cumulative effects of "nuclear development" in the Savannah River Basin, and (2) consider further the cumulative impacts to water resources. In the EIS, the Department has evaluated the potential radiological effects resulting from cumulative Savannah River Plant releases--existing and planned--as well as those from other nuclear facilities in the vicinity of the Plant. The Department has also included additional information on cumulative ground-water withdrawals and on the current status of studies concerning maintenance of Savannah River flow rates below the Clarks Hill dam.

Postulated accidents. The EIS considers a number of postulated reactor accidents that could result in the release of radioactive materials into the environment. These include credible accidents and severe hypothetical accidents that are not considered credible or probable.

The credible accidents include a major moderator spill, the melting of a single assembly during a discharge mishap, the melting of 3 percent of the core caused by a reloading error, and the melting of 1 percent of the core due to a

loss-of-coolant accident. The 3-percent core melt has the highest potential consequences of the credible accidents. The estimated maximum individual whole-body radiation dose received by a person residing at the SRP boundary from this postulated accident is calculated to be 0.39 rem, with a maximum thyroid dose of 1.5 rem. Both of these doses are well below the Nuclear Regulatory Commission's site evaluation dose guidelines of 25 rem and 300 rem for the whole body and thyroid, respectively.

The EIS also discusses an accident beyond those considered credible--a postulated 10-percent core melt--to provide a perspective on the consequences of an accident having an extremely low probability but a potentially great severity. The probability for this accident is estimated to be between 1 in 1 million and 1 in 100 million per reactor-year. The consequences calculated indicate no cases of early fatalities, no cases where the maximum individual whole-body dose would exceed 1.7 rem, and no cases where the thyroid dose would exceed 11.7 rem. Again, the estimated doses from this beyond-credible accident would be well below the Nuclear Regulatory Commission's site evaluation dose guidelines established for commercial power reactors.

To provide a further perspective on the overall accident risk (defined as consequence times probability) of L-Reactor operation, this Final EIS contains a preliminary total risk curve that depicts the annual probability of an individual living at the SRP boundary receiving more than a certain dose from postulated severe accidents. The results shown in this curve were based on the Safety Analysis Report, and include a range of accidents up to low-probability, high-consequence accidents, including hypothetical 100-percent core-melt scenarios at the upper bound of the consequence spectrum.

In addition to postulated reactor accidents, the Final EIS also discusses non-nuclear hazards and such natural phenomena as earthquakes and tornadoes, the evolution of reactor safety at the Savannah River Plant and current programs to improve safety, and emergency planning.

The aspect of the accident analyses that received the most comments concerned the need for a containment building for L-Reactor, the comparability of L-Reactor to the Nuclear Regulatory Commission requirements for commercial nuclear reactor site criteria (10 CFR 100), and the presentation of a "worst-case" analysis.

For the most part, the comments on the need for a containment building were general, often only citing that commercial reactors are required to have them and that L-Reactor is not. The need for pressure containment buildings for commercial light-water reactors is based on their design and site characteristics and on the need for specific engineered safety features. Reactors of different designs and engineered safety features other than a containment building can also limit radioactive releases and be within acceptable standards for a range of postulated accidents. The Fort St. Vrain reactor, which has been licensed by the Nuclear Regulatory Commission, is an example of a commercial reactor without a containment building; its design and engineered safety features are different from those in commercial light-water reactors.

The L-Reactor has several important design features and alternative engineered safety features that must be considered in any comparison with commercial light-water reactors. For example, L-Reactor operates at much lower pressures

and temperatures than commercial light-water reactors; thus, the stored energy in a postulated loss-of-coolant accident--which is of primary concern in the need for a containment building--is much less. Other important differences exist for operational limits, emergency shutdown systems, the confinement system, the type of fuel, and the distance to the nearest site boundary. These differences, considered in the analysis of credible accident events and resultant consequences, indicate that L-Reactor with its confinement system would meet the Nuclear Regulatory Commission's radiation protection site evaluation factors for a commercial reactor.

Other comments received on the need for a containment building concerned the comparability of the accident analyses for L-Reactor to the Nuclear Regulatory Commission's requirements for reactor site criteria (10 CFR 100). Specifically, commentators contended that a postulated 100-percent core-melt accident was the proper basis for assessing the safety comparability of L-Reactor to commercial reactors. They also contended that if the 100-percent core-melt accident were used as the basis, L-Reactor would not meet the Nuclear Regulatory Commission's site evaluation factors.

The requirements of 10 CFR 100 do not assume or require the assumption of a full-core (100-percent) meltdown as a basis for assessing consequences, as contended. These requirements clearly indicate analyses of "... accidental events, that would result in potential hazards not exceeded by those from any accident considered credible." Again, the design differences between reactors and different engineered safety features must be considered in determining "accidents considered credible." In recognition of the high-heat capacity of the Fort St. Vrain graphite-moderated reactor, for example, no fuel melting was assumed in specifying the source term for determining compliance with 10 CFR 100. Similarly, the most severe credible L-Reactor accident is a postulated criticality accident that results in a 3-percent core melt. The postulated criticality accident, rather than the loss-of-coolant accident used for commercial light-water reactors, reemphasizes the differences in the design and engineered safety systems between L-Reactor and commercial light-water reactors.

Finally, commentators contended that the Draft EIS failed to present a worst-case analysis. Specifically, they asserted that the EIS should have presented the consequences of a 100-percent core-melt accident with a concurrent failure of the active confinement system, rather than those of a 10-percent postulated core-melt accident.

The Department of Energy recognizes uncertainties inherent in its predictions of the probabilities and consequences of extremely low-probability but high-consequence accidents. The worst-case analysis required by NEPA is intended to provide the decisionmaker with information that balances the need for the action against the risk and severity of possible adverse impacts if the action proceeded in the face of uncertainty. The "uncertainty" in this instance, however, is not one that questions the severity of the consequences if this class of accident were to occur, but rather the degree of improbability of its occurrence (i.e., whether once in 10 million years or once in a billion or more years). The detailed analyses of the very-low-probability, 10-percent, core-melt accident, together with available information on the consequences and probabilities of a spectrum of more severe but even less probable accidents included in the EIS are judged to provide the decisionmaker with sufficient information for this purpose.

Summary of Environmental Effects

Table S-1 summarizes and compares the environmental consequences of the Department's preferred alternative and the no-action alternative.

Monitoring and Studies

In addition to its extensive environmental studies on L-Reactor, the Department of Energy has begun several long-range studies to determine the Savannah River Plant's overall effect on the health and environment of people who live in nearby areas. These studies are intended to identify any further improvements that can be made to SRP operations.

The Department is committed to making whatever modifications might be necessary to ensure that SRP operations do not pose an undue risk to the local environment or to public health. Representatives of Federal and state agencies are active participants in these studies. The studies initiated by the Department of Energy relate to four basic areas, which are summarized below.

Cooling water. The Department initiated a 2-year study in July 1983 to further assess the effects of SRP thermal discharges on the Savannah River ecosystem, including all major streams that flow to the river and adjacent wetlands. The study is an expansion of ongoing studies concerning the three operating reactors, steam plant operations, and the proposed operation of L-Reactor.

Participating in the study are the States of South Carolina and Georgia, the U.S. Environmental Protection Agency (Region IV), the U.S. Fish and Wildlife Service (Region IV), and the U.S. Army Corps of Engineers (South Atlantic Division).

This study is examining the environmental effects associated with cooling-water withdrawal and thermal discharges. It is assessing wetland impacts, impacts to fish populations, utilization of the SRP wetlands and streams by aquatic and semiaquatic species, including endangered species, water-quality parameters, and radionuclide and heavy-metal transport. The study is assessing spawning areas at intervals along the river and near the mouth of tributaries from Augusta downstream to the area of salt-water intrusion.

Thermal mitigation. The Department will consider alternatives to the direct discharge of cooling water for all major SRP thermal discharges from operating facilities. Among the alternative systems being evaluated are cooling towers, cooling ponds, and spray cooling systems.

Ground water. Continued efforts are being made to safeguard ground-water systems by removing contaminants from the water-table aquifer in the Fuel and Target Fabrication Area. In addition, the Department is committed to stopping all further use of the seepage basin at the fuel fabrication facility by April 1985. The "SRP Groundwater Protection Implementation Plan" will be the subject of a separate NEPA review.

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative

Impact	Preferred Alternative ^a	No Action ^b
Land use and socioeconomics	1000 acres would be required for the construction of the cooling lake and about 130 acres of land for relocating roads and right-of-ways; operating workforce of about 350 required as well as 550 temporary construction workers for lake construction.	No additional land would be required; standby workforce of about 100 will be required; approximately 330 operating jobs would be lost.
Archeological sites	Five sites eligible for inclusion in the <u>National Register</u> might be affected; a approved resource recovery plan has been developed for one historic site located within the proposed lake area; archeologic studies in the lake area are continuing and mitigative measures will be taken if significant sites are found.	Some erosional impacts are anticipated from cold flow testing to the eligible sites.
Cooling-water withdrawal	L-Reactor will withdraw about 400 cubic feet (11 cubic meters) per second, or about 4% of the average annual flow rate and 7% of the 7-day, 10-year low flow of the Savannah River; withdrawal will cause impingement of an additional 16 fish per day, and entrainment of about 3 to 6% of all fish eggs and larvae passing the SRP intakes when L-Reactor is operating under average conditions.	Testing and flushing of secondary cooling-water system approximately several days per month at flows up to 6.2 cubic meters per second; impingement and entrainment impacts during these test periods will be about one-half the impacts for the preferred alternative.
Cooling-water discharge	L-Reactor will discharge about 400 cubic feet (11 cubic meters) per second of cooling water to the 1000-acre lake; reactor power will be adjusted to assure a balanced biological community in the lake; projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp, and the mouth of Steel Creek would be within about 2°F (1°C) of ambient; average values of water temperatures at the mouth of Steel Creek are projected to be 82°F, 72°F, and 55°F (28°C, 22°C, and 13°C) during summer, spring, and winter, respectively; the 5-day, worst-case value during summer is projected to be 86°F (30°C) or within about 2°F (1°C) of ambient.	No thermal discharges to Steel Creek; however, minor impacts during periods of testing would occur due to flooding and siltation.

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Wetlands/ habitats	1000-acre lake would affect between 735 and 1015 acres of wetlands/habitats in the Steel Creek corridor, delta, and Savannah River swamp, and about 875 acres of upland; cooling lake would provide a balanced biological community in the lake; delta growth would resume at about 1-2 acres per year; DOE is working with the Department of Interior on use of the Habitat Evaluation Procedure to identify further mitigation.	Minor impacts during periods of testing.
Aquatic impacts	Minor impacts downstream of the embankment to the delta due to flooding and siltation; spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta would not be affected except in winter when the water temperatures would be 12°F to 16°F (7° to 9°C) above ambient; cold shock effects would be minimal due to gradual heat loss after shutdown; the lake embankment would prevent access by riverine and anadromous fish to about 100 acres of Steel Creek wetlands above L-Reactor, however, the only migratory fish in this reach of Steel Creek is the American eel which can access the lake; access to Meyers Branch would not be affected by the lake.	No thermal discharges to Steel Creek; however, minor impacts during periods of testing would occur due to flooding and siltation.
Endangered species	Increased flow from the cooling lake would affect foraging habitat for the wood stork, and the habitat for the American alligator; additional habitat for alligator would be created by the lake; consultation with FWS continuing for both species; no impacts to shortnose sturgeon.	Habitat for wood stork and American alligator could be affected intermittently during cold flow testing. No impacts to the shortnose sturgeon.
Water quality	Liquid effluents discharged would have chemical characteristics similar to those in the Savannah River.	No impacts. Periodic cold-water testing discharges would have chemical characteristics similar to those in the Savannah River.

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Ground-water quality		
L-Area	Disassembly-basin purge water containing principally tritium will be discharged to the L-Reactor seepage basin; shallow ground water will become contaminated by discharges that will eventually discharge to the cooling lake in about 20 years; the use of the seepage basin will allow radioactive decay; deeper groundwater sources will be protected by clay barriers; DOE will continue to study the feasibility of moderator detritiation.	No discharges to the L-Area seepage basin.
M-Area	Incremental discharges increased by 33 percent; by the end of 1984, incremental discharges will be reduced by 80 percent; contaminants will be intercepted by remedial action program; a new treatment facility will replace seepage basin use by April 1985.	Same as for preferred alternative except effluents from ongoing operations will continue without incremental increase due to L-Reactor.
F- and H-Areas	Incremental discharge to seepage basins would result in a 7 percent increase in concentration of contaminants in shallow groundwater; deeper formations would be protected by confining clay units; treatment facilities to replace seepage basins use when Congressional approval obtained.	Same as for preferred alternative except effluents from ongoing operations will continue without incremental increase due to L-Reactor.
Ground-water use	A total of 210 cubic feet (5.9 cubic meters) per minute will be withdrawn from the Tuscaloosa aquifer for L-Reactor and its support facilities; total ground-water withdrawal by SRP is projected to be 7% greater than in 1982.	Ground-water withdrawal of 33 cubic feet (0.94 cubic meter) per minute is required.
Air quality	Operational emission from K-Area would increase by 10 percent consisting primarily of NO _x , SO _x , and particulate matter; some fugitive dust emissions would occur during construction of lake; no detectable impact on local or regional air quality is expected.	No change from present operations; no detectable impact on air quality would be expected.

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Solid waste	All unsalvageable domestic trash would be packaged and disposed of in SRP landfill; sanitary waste sludge would be disposed of at the SRP sludge pit; bottom ash sluiced to the K-Area ash basin would increase by 10%.	No change from present operations.
Radiological releases and effects		
Radiocesium	About 4.4. curies of radiocesium would be transported during the first year and about 20-25 percent less each year; radiocesium releases would not exceed any applicable standards or affect public health and safety.	Small amounts would be resuspended during periodic testing and flushing.
Radiation dose	Maximum individual dose of 3.6 millirem in the first year, or about 26 times less than the average received by an individual living near SRP from natural radiation; total-body dose to both the 50-mile (80-kilometer) and downstream river-water-consuming populations of 36 person-rem (tenth year), or less than 0.032 percent of the dose from natural background radiation.	No radioactive releases from L-Reactor or incremental releases from support facilities.
Health effects	Estimated health effects in the first year about 0.003 premature cancer death and 0.006 genetic disorder; releases during the tenth year would eventually cause about 0.006 premature cancer death and 0.01 genetic disorder.	No radioactive releases from L-Reactor or incremental releases from support facilities.
Accidents	Accidents are highly unlikely; safety systems at SRP have been improved to further reduce the chance of an accident; small additional risks.	L-Reactor would not operate nor would there be incremental use of support facilities.

^aThe preferred alternative is to restart L-Reactor as soon as practicable after construction of a 1000-acre lake. Impacts identified are those from the operation of L-Reactor and incremental increases at support facilities.

^bNo action is defined as maintaining L-Reactor in a ready-for-operation standby mode.

Health effects. The Department is continuing health effects studies of cancer mortality rates in the areas around SRP. These studies concentrate on those types of cancer for which a proven causal relationship with radiation exposure has been demonstrated. To date, no correlations have been established between population cancers and SRP operations.

Health studies of SRP employees are also being conducted by the Occupational Epidemiology Section of the Oak Ridge Associated Universities, and by the Epidemiology Group at Los Alamos National Laboratory, both of which are DOE laboratories. The Oak Ridge morbidity and mortality studies of radiation workers and the Los Alamos studies of plutonium workers are in the early stages.

At DOE's request, the Centers for Disease Control in Atlanta has organized a review committee of independent experts to review the results of population health effects studies and occupational epidemiological studies. Epidemiologists from the States of South Carolina and Georgia are participating in this study. The Department will adopt recommendations of this panel to modify its existing studies and to conduct additional studies.

Comments on monitoring and studies in the Draft EIS consisted for the most part of those that requested "independent" oversight or review of Savannah River Plant activities, and those that were concerned with particular aspects of the annual SRP monitoring program. The Department of Energy has attempted to respond to these concerns in this Final EIS by describing the interactions that are currently taking place with state and Federal agencies, the monitoring programs being conducted by the States of South Carolina and Georgia, and its ongoing commitment to adhere to applicable regulations and standards that will ensure continued protection of the area population's health and safety.

Federal and State Environmental Requirements

Table S-2 lists the permits and other environmental approvals required for the Department's preferred alternative before L-Reactor operation can resume. It indicates the status of each requirement. Based on the comments received on the Draft EIS and the identification of a preferred cooling-water mitigation alternative, the discussion of Federal and state environmental requirements has been expanded in this Final EIS.

Table S-2. Required regulatory permits and notifications

Activity/facility	Requirement(s)	Agency	Status
Water			
Process and sanitary-sewer outfalls	NPDES permit Construction permit	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Discharges permitted Construction permitted
Domestic water supply system	Permit to construct ground-water wells, treatment and distribution systems	South Carolina Department of Health and Environmental Control, Water Supply Division	Domestic water-supply system construction permitted
Cooling-water discharge	316(a) (thermal impact) study	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	See Appendix L
Cooling-water discharge, preferred alternative (1000-acre lake)	NPDES permit	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Pending completion of FEIS
	Dredge and fill permit (Section 404)	U.S. Army Corps of Engineers	Pending completion of FEIS
	Certification (Section 401)	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Requested by COE as part of the dredge and fill permit process

Table S-2. Required regulatory permits and notifications (continued)

Activity/facility	Requirement(s)	Agency	Status
Oil storage	Spill prevention, control and counter-measure plan	EPA/South Carolina Department of Health and Environmental Control	To be included in overall plan for SRP
Air			
L-Area emergency diesel generators	Operation permits	South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control	Permitted
F-, H, and M-Area process facilities	Operation permit amendments	South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control	Application under review
K-Area powerhouse	Operation permit	South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control	New permit not required
Endangered species	Consultation/biological assessment	U.S. Fish and Wildlife Service and National Marine Fisheries Service	Consultations with FWS in process; consultations with NMFS completed
Fish and Wildlife Coordination Act	Consultation/consideration of fish and wildlife resources	U.S. Fish and Wildlife Service	Consultations with FWS in progress
Migratory Bird Treaty Act	Consultation with FWS and development of mitigation plan	U.S. Fish and Wildlife Service	Consultation with FWS in progress

Table S-2. Required regulatory permits and notifications (continued)

Activity/facility	Requirement(s)	Agency	Status
Anadromous Fish Conservation Act	Consultation with FWS and development of mitigation plan	U.S. Fish and Wildlife Service	Consultation with FWS in progress
Historic preservation	Archeological survey and assessment	South Carolina Historic Preservation Officer	1000-acre lake will require new survey compliance, etc.
Floodplain/wetlands	Assessment and determination	U.S. Department of Energy	To be updated based on FEIS
Hazardous wastes	Resource Conservation and Recovery Act Requirements	U.S. Department of Energy/ South Carolina Department of Health and Environmental Control/U.S. Environmental Protection Agency	RCRA Program Management Plan in place

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1 NEED FOR RESUMPTION OF L-REACTOR OPERATIONS AND PURPOSE OF THIS ENVIRONMENTAL IMPACT STATEMENT

The U.S. Department of Energy (DOE) operates two nuclear reactor production complexes for the purpose of producing plutonium and tritium for the nation's defense programs; these complexes are the Savannah River Plant (SRP) in South Carolina and the Hanford Reservation in Washington State. Three SRP reactors (C, K, and P) are presently operating; they produce the majority of the plutonium and all the tritium used for defense programs. At Hanford, one production reactor, the N-Reactor, is being operated in a combined mode to produce plutonium for defense programs and steam for electric power generation.

Current forecasts of nuclear material needs for defense programs indicate that these existing production complexes have insufficient capacity to meet projected plutonium requirements. To prevent shortages, especially during the next few years, DOE proposes to resume operation of L-Reactor at the Savannah River Plant as soon as practicable. This proposed action is one of a series of production initiatives being taken to increase the supply of weapons-grade plutonium to a level that will satisfy the projected requirements.

1.1 NEED

1.1.1 Defense nuclear materials

The responsibilities of DOE in the area of defense programs stem from the Atomic Energy Act of 1954, as amended. This legislation establishes the Department's responsibility to develop and maintain a capability to produce all nuclear materials required for the defense programs of the United States.

In 1980, a high-level Policy Review Committee (members included the Secretaries of State, Energy, and Defense), under the auspices of the National Security Council, was convened to assess changes needed in the nation's nuclear weapons stockpile. The committee determined that the stockpile should be increased and that additional nuclear material production capacity will be required to meet the increased requirements. Also, the committee determined that a number of new production initiatives should be started at that time. The increased requirements were defined in the fiscal year (FY) 1981-1983 Nuclear Weapons Stockpile Memorandum (NWSM), approved by President Carter on October 24, 1980.

The Nuclear Weapons Stockpile Memorandum is the document by which the President annually authorizes the production and retirement of nuclear weapons. In the memorandum, the Secretaries of Defense and Energy jointly recommend to the President the size and composition of the nuclear weapons stockpile they believe is required to defend the United States. In the development of this memorandum many factors are considered, such as the needs of the armed services; the current status of legislative actions concerning weapons systems and production capability; and the current status of material inventory, material supply from weapon retirements, material production and weapons fabrication. Included

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in the memorandum to the President is the plan for producing the nuclear materials required to support the nuclear weapons stockpile. The Nuclear Weapons Stockpile Memorandum is forwarded to the President through the National Security Council. In accordance with the Atomic Energy Act, approval of the NWSM by the President and subsequent authorization and appropriation of funds by the Congress constitute the legal authority and mandate to DOE to produce the specified types and quantities of nuclear materials and weapons. If significant changes occur after the development of an NWSM, such as Congressional action that potentially affects material supply and demand, DOE factors the impact into its implementation of the NWSM requirements after the Department of Defense formalizes the modified requirements.

The increased requirements authorized in the FY 1981-1983 Nuclear Weapons Stockpile Memorandum resulted from efforts to modernize and improve stockpiled nuclear weapons, as well as to provide warheads for new weapons systems scheduled for deployment during the next decade. The program to modernize existing weapons systems involves replacing older nuclear warheads and existing delivery systems with modern, safer, and more effective warheads. Modernization, in many instances, has led to replacing older warheads that used uranium enriched in the isotope uranium-235 with new warheads that use weapons-grade plutonium.

The increased defense nuclear material requirements and the production initiatives necessary to provide the resultant additional production capacity have been reaffirmed in subsequent Stockpile Memoranda since 1980, including the FY 1984-1989 NWSM. Congress has generally supported, through authorization legislation and appropriation of funds, the initiatives necessary to produce the needed additional nuclear materials.

The current nuclear materials requirements for defense programs come from the FY 1984-1989 NWSM, approved by President Reagan on February 16, 1984. This document defines the annual requirements for defense nuclear materials for the first 5 years (FY 1984-1989), the planning directives for the next 5-year period, and 5 additional years of projections for long-range planning. In his approval of the FY 1984-1989 Nuclear Weapons Stockpile Memorandum, President Reagan emphasized the importance of meeting these annual requirements and maintaining an adequate supply of defense nuclear materials by directing that: ". . . as a matter of policy, national security requirements shall be the limiting factor in the nuclear force structure. Arbitrary constraints on nuclear material availability . . . shall not be allowed to jeopardize attainment of the forces required to assure our defense and maintain deterrence. Accordingly, DOE shall . . . assure the capability to meet current and projected needs for nuclear materials and . . . restart the L-Reactor at the Savannah River Plant, Aiken, S.C., as soon as possible."

During the fall of 1983, the Departments of Energy and Defense developed the FY 1984-1989 NWSM. This NWSM incorporated the changes in proposed weapon systems that had occurred since the FY 1983-1988 NWSM was prepared, as well as the modified material inventory requirements and material supply from weapon retirements. Changes have affected the required delivery of defense nuclear materials, because Congress has delayed or did not fund certain nuclear weapons systems mentioned in the FY 1983-1988 NWSM; however, the production capacity of the implemented and proposed initiatives is still needed to meet the requirements of the FY 1984-1989 NWSM.

Certain events that have occurred since the development of the FY 1984-1989 NWSM have the potential of affecting the supply and demand for defense nuclear materials; these include the Congressional action to delete DOE funding for production facilities for the warhead for the 155-mm artillery-fired atomic projectile (AFAP). This warhead (W82) was intended to replace the W48 warhead, which is currently scheduled for retirement. The impact of the Congressional action on the need for material has not yet been determined; however, its effect and that of any other subsequent events will be factored into the implementation of the FY 1984-1989 NWSM when DOD requirements are revised to reflect Congressional actions. Because the Department of Defense has indicated that the retirement schedule for the W48 warhead will depend on the deployment of the W82, the Congressional action on the W82 warhead is not anticipated to result in a major impact on the need for the restart of L-Reactor.

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1.1.2 Need for L-Reactor

When the call for additional nuclear material was made by the National Security Council in 1980, there was insufficient operating capacity in the existing DOE production complexes to meet the increased requirements for both tritium and weapons-grade plutonium.* As a consequence, all identifiable production options were evaluated and the most timely and cost-effective options were implemented. These implemented initiatives included

- Altering the Hanford N-Reactor operating cycle to produce weapons-grade plutonium rather than fuel-grade plutonium.
- Restarting the PUREX Separations Plant at Hanford to recover the plutonium from the spent N-Reactor fuel in storage (primarily of high Pu-240 content) and the fresh spent fuel (6-percent Pu-240). The stored N-Reactor spent fuel is being sorted such that spent fuel with lower Pu-240 content can be processed first.
- Shortening the SRP reactor operating cycles to produce 3-percent Pu-240 assay plutonium rather than 6-percent Pu-240.
- Blending higher assay Pu-240 plutonium either from DOE-owned plutonium presently in inventory or from plutonium to be recovered from the operation of the Hanford PUREX Plant with the 3-percent Pu-240 plutonium being recovered at SRP to produce weapons-grade plutonium.

BL-19

*Weapons-grade plutonium is primarily Pu-239 and contains less than 6-percent Pu-240. The term "fuel-grade" plutonium is used to refer to plutonium containing greater than 6-percent Pu-240, generally 9- to 14-percent Pu-240.

Figure 1-1 shows current operations and implemented initiatives; the implemented initiatives are described below.

The N-Reactor at the Hanford Reservation in Richland, Washington, operated strictly as a plutonium production reactor from its startup in December 1962 until April 1966. Since April 1966, the byproduct steam from N-Reactor has been used to produce electrical power in the adjacent steam plant belonging to the Washington Public Power Supply System. Before 1973, N-Reactor was operated part of the time to produce 9-percent Pu-240; the rest of the time, it produced weapons-grade plutonium (6-percent Pu-240).

From 1973 to 1982, N-Reactor produced plutonium with a Pu-240 content of approximately 12 percent. In 1982, it was switched from the production of fuel-grade to the production of weapons-grade plutonium. This conversion was to 6-percent Pu-240. In the 6-percent Pu-240 production mode, the schedule requires the shutdown and discharge of approximately one-fourth of the core eight times a year (rather than only four times a year for the 12-percent Pu-240 production program). Therefore, the fuel throughput increased by a factor of two, which required operational changes in fuel fabrication, reactor charge and discharge operations, the storage of spent fuel, and reprocessing.

BL-21 The PUREX Separations Plant at Hanford is a large, remotely operated and maintained nuclear fuel reprocessing plant. It contains equipment for chemically dissolving nuclear fuel, recovering uranium and plutonium from solution by the PUREX solvent extraction process, and converting the chemically purified plutonium to solid plutonium oxide for shipment. Uranium is recovered as a concentrated nitrate solution, which is converted to an oxide powder in the Hanford uranium oxide plant; liquid wastes are neutralized and stored in tanks.

The PUREX Separations Plant operated from 1956 to 1972, when it was placed on standby. The resumption of PUREX Plant operations was authorized and funded in FY 1981. At that time, the predicted date for the PUREX Plant to resume operation was April 1984; however, the plant was restarted 5 months ahead of schedule. The PUREX Plant itself does not produce plutonium; it separates reactor-produced plutonium from uranium and waste products. The operation of this plant will maximize the amount of weapons-grade plutonium available for defense programs by processing the lower Pu-240 material first.

The early restart of the PUREX Plant will have a minor effect on the supply of weapons-grade plutonium during the timeframe of concern for L-Reactor, because sufficient supplies of fuel-grade plutonium are available in inventory for blending; in addition, the capacity of the PUREX facility is large in comparison with the backlog of N-Reactor weapons-grade material available for processing. Furthermore, the early plant restart was factored into the material supply information in the FY 1984-1989 NWSM approved by President Reagan on February 16, 1984.

Environmental effects for resuming operation of the PUREX Plant are discussed in the Final Environmental Impact Statement for PUREX Operation (DOE/EIS-0089).

Initially, most of the material the PUREX plant will recover will be a high-assay Pu-240 (greater than 6-percent) product. The recovery rate will exceed the availability of 3-percent Pu-240 produced at SRP for blending.

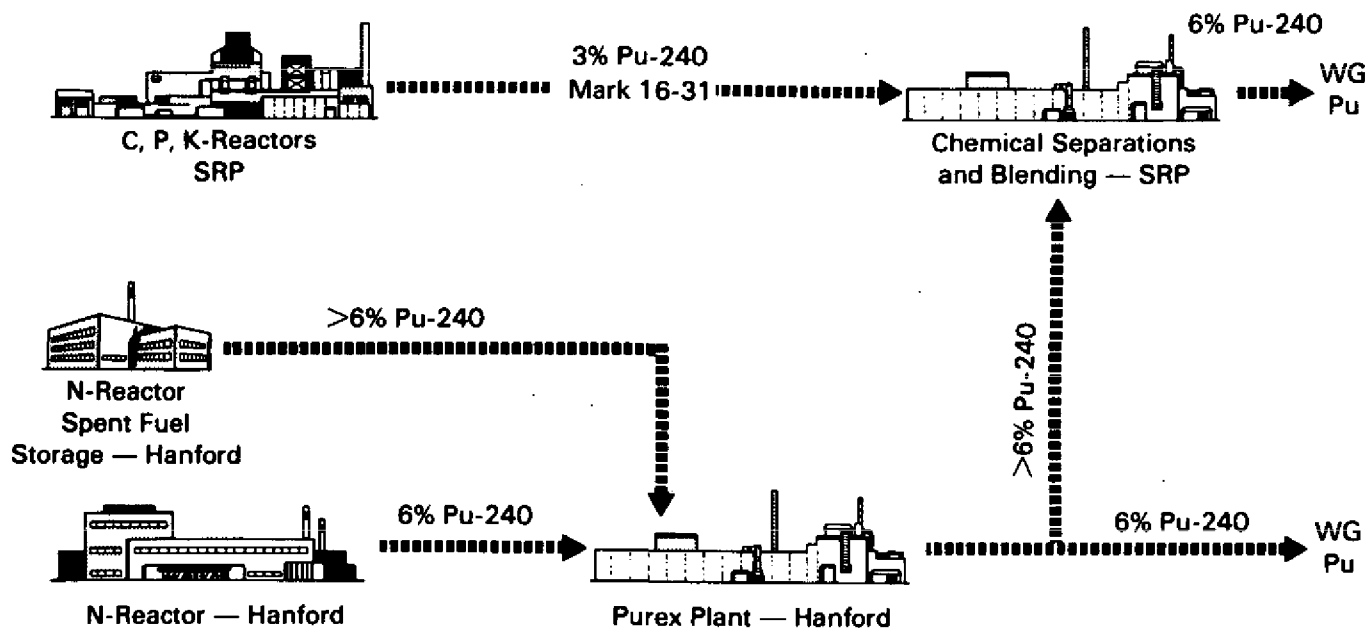


Figure 1-1. Current and implemented initiatives to produce weapons-grade (WG) plutonium (Pu).

Although PUREX will not always operate at full capacity during the 1980s, the available extra capacity cannot be put to any other practical use. The proposed operation of L-Reactor would accelerate the use of high-assay Pu-240 processed at PUREX because L-Reactor would produce additional 3-percent Pu-240 material for blending.

BL-21 Spent fuel from N-Reactor has been accumulating in Hanford storage basins since the shutdown of the PUREX Separations Plant in 1972; this spent fuel is being reprocessed by the PUREX Plant. Although the N-Reactor has been operating with a nominal 12-percent Pu-240 content in its discharged fuel, the actual Pu-240 content varies from about 5 percent to 19 percent, depending on the fuel position within the reactor and its actual exposure. Physically sorting the fuel into batches (which started in 1983) before reprocessing allows the 6-percent Pu-240 assay fuel to be reprocessed first, thus making it available for early processing in the PUREX Plant. This plutonium is not a net gain to the system, however, because the remaining fuel-grade material produced from the PUREX Plant is blended at a slower rate due to its higher Pu-240 content.

Blending involves the conversion of fuel-grade plutonium to weapons-grade plutonium; this conversion occurs by mixing plutonium with less than 6-percent Pu-240 with plutonium containing greater than 6-1/2-percent Pu-240. One of the production initiatives undertaken in 1981 was to convert the SRP reactors to the production of 3-percent Pu-240. The major sources of high-assay Pu-240 for blending are spent fuel from N-Reactor and other DOE fuels containing plutonium originally processed at Hanford. The blending program was initiated with the use of existing inventories of fuel-grade plutonium.

The blending operation at SRP provides about a 50-percent increase in the amount of available weapons-grade plutonium, based on a nominal 12-percent Pu-240 content in existing spent fuel. Specific annual production rates of low-assay Pu-240 plutonium vary because tritium demand is satisfied before plutonium production at SRP, and tritium demand varies from year to year.

These implemented initiatives produce a substantially greater amount of plutonium, but not enough to fully meet the nuclear defense material requirements. To provide more plutonium production, DOE has proposed several additional initiatives for implementation; these proposed initiatives, shown in Figure 1-2, are to:

- Restart the restored L-Reactor at the Savannah River Plant.
- Use an improved fuel lattice (Mark 15) in the SRP reactors to produce significantly more plutonium than the present Mark 16-31 plutonium-producing lattice.
- Construct a special isotope separations (SIS) plant to process and convert fuel-grade plutonium into weapons-grade plutonium.

BL-21 The Mark-15 homogeneous lattice has been designed to be the most efficient plutonium core that can be accommodated at SRP. It consists of a uniform reactor lattice using slightly enriched uranium fuel (the Mark 16-31 plutonium-producing lattice currently employed at SRP uses highly enriched and depleted

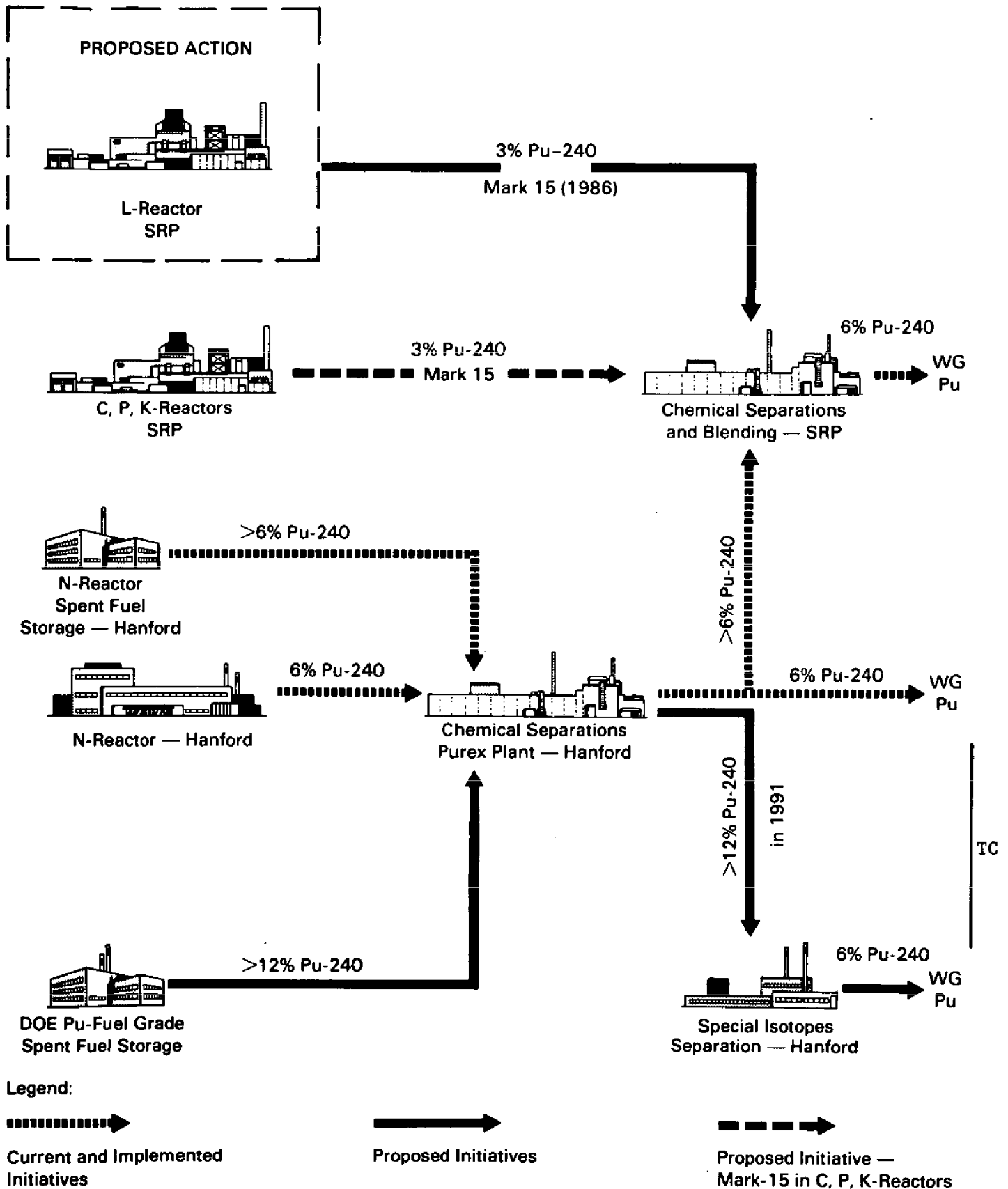


Figure 1-2. Current, implemented and proposed initiatives to produce weapons-grade (WG) plutonium (Pu).

BL-21 | uranium elements). A demonstration Mark 15 lattice was operated successfully in the K-Reactor at SRP in August 1983. Implementation of the Mark 15 lattice is planned for late 1986.

Since 1972, the N-Reactor at Hanford has produced fuel-grade plutonium of high-assay Pu-240 for use in reactor studies and other DOE programs. Also, DOE has other fuel-grade plutonium stocks [e.g., Fast Flux Test Facility (FFTF)] that can be processed and fuel-grade plutonium that can be recovered in the PUREX Plant. Processing some of these spent fuels will require a shear-leach head-end addition to the PUREX Plant.

CX-4 | The Department of Energy is currently proceeding with the development of the special isotope separation (SIS) process as a method to convert fuel-grade plutonium into weapons-grade plutonium. This process has been demonstrated only in the laboratory. The FY 1984-1989 NWSM is based on a scale-up to a full-production facility by 1991. This plant could be used for the isotopic purification of existing fuel-grade plutonium produced from past operation of the N-Reactor and from spent FFTF fuel.

AB-8 | An alternative considered for production of defense nuclear materials after 1985 (the far-term) is the construction and operation of a New Production Reactor (NPR). The estimated time from the authorization of an NPR to its startup is about 10 years. Thus, an NPR could not contribute to material production until 1995 at the earliest, much too late to help offset the near-term need for defense nuclear materials.

BL-19, EN-10 | The proposed restart of the L-Reactor at the Savannah River Plant, originally scheduled for October 1983, is the subject of this environmental impact statement. All the initiatives discussed above, including L-Reactor restart, are needed as soon as practicable to meet the increased defense nuclear material requirements. Any delays will directly affect the needed supply of defense nuclear materials for our Nation's nuclear force structure.

The President emphasized the importance of the timely restart of L-Reactor to increase the supply of nuclear material in his approval of the FY 1984-1989 Nuclear Weapons Stockpile Memorandum, on February 16, 1984, as follows: ". . . DOE shall . . . restart the L-Reactor at the Savannah River Plant, Aiken, South Carolina, as soon as possible."

This discussion on the need for L-Reactor is, by necessity, qualitative and limited because quantitative information on defense material requirements, inventories, production capacity, and projected material shortages or adverse impacts on weapons-system deployments is classified. A quantitative discussion of the need for restarting L-Reactor, including the impacts of delaying the restart, is provided for the DOE decisionmaker in a classified appendix (Appendix A).

1.2 PURPOSE

The purpose of this environmental impact statement is to analyze the potential environmental consequences of the proposed resumption of L-Reactor operation and its alternatives in compliance with Section 102(2)(C) of the National Environmental Policy Act of 1969, as amended, and the Energy and Water Development Appropriations Act, 1984. Also, on July 15, 1983, the U.S. District Court, acting on a November 1982 lawsuit, directed the DOE to prepare and publish an environmental impact statement as soon as possible on the proposed operation of L-Reactor.

The proposed action is to resume operation of L-Reactor as soon as practicable. The Department of Energy's preferred alternative is to operate L-Reactor after construction of a 1000-acre once-through cooling lake. TC

An environmental assessment on the L-Reactor restart was issued earlier in August 1982 (DOE, 1982a). This EIS describes production options considered (Chapter 2) and the affected SRP environment (Chapter 3), and assesses the potential environmental consequences of the resumption of L-Reactor operation and describes potential mitigation alternatives (Chapter 4).

Chapter 5 addresses incremental effects from other SRP facilities that would occur due to the resumption of L-Reactor operation and potential cumulative effects with nearby nuclear facilities.

Chapter 6 describes programs to study and monitor effluents from the SRP facility and to assess the ecological health of the SRP environment. Chapter 7 summarizes Federal and State of South Carolina requirements that apply to the proposed resumption of L-Reactor operation. Chapter 8 describes the unavoidable/irreversible impacts of L-Reactor operation.

Two EISs that address SRP waste-management operations and that are relevant in understanding potential environmental effects of the resumption of L-Reactor operation have been published in the last 6 years. The Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina (ERDA, 1977) describes the waste-management operations of the Savannah River Plant and analyzes their actual and potential environmental effects. The Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina (DOE, 1982b) describes the disposal strategy and the construction and operation of facilities at the Savannah River Plant to immobilize defense high-level radioactive wastes and analyzes the potential environmental effects.

The "SRP Ground-Water Protection Implementation Plan" will be the subject of a separate NEPA review. This review will cover such topics as seepage-basin decommissioning, cleanup levels, costs, schedules, and the need for institutional controls.

REFERENCES

- DOE (U.S. Department of Energy), 1982a. Environmental Assessment, L-Reactor Operation, Savannah River Plant, Aiken, South Carolina, DOE-EA-0195, Washington, D.C.
- DOE (U.S. Department of Energy), 1982b. Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina, DOE/EIS-0082.
- ERDA (U.S. Energy Research and Development Administration), 1977. Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina, ERDA-1537.

2 PRODUCTION OPTIONS AND PROPOSED ACTION

This chapter describes the production options considered by the Department of Energy (DOE) to meet the established requirements for defense nuclear materials. Section 2.1 describes the production options to the restart of L-Reactor. Section 2.2 describes the proposed action; Section 2.3 describes the no-action alternative, which would keep the restored L-Reactor in a ready-for-operation standby mode. The summary to this chapter is contained in Section 2.4, which describes the preferred cooling-water mitigation measure within the proposed action.

TC

Section 4.4 describes mitigation, as opposed to production, alternatives. Each cooling-water mitigation alternative encompasses two options: mitigation before restart and mitigation implemented after the reactor has operated for a period of time. Each mitigation alternative is associated with an inherent delay in production; the length of each delay depends on the particular alternative selected. As with production options, any delay in restarting L-Reactor to implement a mitigation option entails a loss of needed production that cannot be fully compensated.

This discussion on production options to L-Reactor is, by necessity, qualitative and limited because quantitative information on defense material requirements, inventories, production capacity, and projected material shortages or adverse impacts on weapons-system deployments are classified. A quantitative discussion of the need for restarting L-Reactor, including the impacts of delaying the restart, is provided for the DOE decisionmaker in a classified appendix (Appendix A).

2.1 PRODUCTION OPTIONS TO L-REACTOR

The production options to L-Reactor consist of those that have production capacities similar to those for L-Reactor and those that have only partial capacities when compared to L-Reactor. The production options described below can be categorized as either "full" or "partial"; they are described in the following sections.

The following full-production options were assessed:

- Restarting R-Reactor at the Savannah River Plant
- Restarting one of the K-Reactors at the Hanford Reservation
- Processing commercial reactor spent fuel

TC

The following partial-production options were also assessed:

- Increased power in the operating SRP reactors
- Increased power in the N-Reactor at Hanford
- Production of less-than-3-percent plutonium-240 in the operating SRP reactors

- Production of less-than-6-percent plutonium-240 at the N-Reactor
- Accelerated use of the Mark-15 fuel lattice in the operating SRP reactors
- Combinations of partial-production options

2.1.1 Full-production options

Possible full-production options have been analyzed. Existing production reactors were considered, as was the use of spent fuel from commercial power reactors. The options that have capacities similar to those for L-Reactor include the restart of either R-Reactor at the Savannah River Plant (SRP) or one of the K-Reactors at the Hanford Reservation, and recovery of plutonium from commercial power-reactor spent fuel.

2.1.1.1 Restart of R- or K-Reactor

Restart R-Reactor at the Savannah River Plant, South Carolina

R-Reactor began operation in late 1953 and was placed in standby status in mid-1964 due to a decline in the need for defense nuclear materials. Since R-Reactor was placed in standby status, its systems and components have not been maintained as well as those in L-Reactor. Because no heating or ventilation was provided since its placement in standby, extensive deterioration is evident throughout R-Reactor. In addition, many R-Reactor components have been removed for use in operating SRP reactors (Turcotte, Palmiotto, and Mackey, 1983).

R-Reactor would require more extensive restoration than L-Reactor. An estimated minimum of 5 years would be required for its restoration to a safe and reliable operating condition; it would also require substantially higher costs for renovation than L-Reactor. Although a restored R-Reactor would have a comparable production rate to L-Reactor, its restart is not considered a reasonable production option to L-Reactor because of timing considerations.

Restart of K-Reactors at the Hanford Reservation, Washington

K-West (KW) and K-East (KE) Reactors at the DOE Hanford Reservation began operation in 1955 and were shut down in 1970 and 1971, respectively, due to a decline in the need for defense nuclear materials. The K-Reactors have been retired and are being prepared for decontamination and decommissioning. The fuel fabrication plant has been dismantled and some essential equipment has been removed. More than 5 years would be required to restore either K-Reactor for the production of plutonium (Turcotte, Palmiotto, and Mackey, 1983).

Because these reactors have been retired and are being prepared for decommissioning, they cannot contribute to the production of plutonium to meet

present and near-term needs; therefore, the restart of either K-Reactor is not considered a reasonable production option to the restart of L-Reactor.

2.1.1.2 Commercial reactor spent fuel

Theoretically, weapon materials could be produced directly in existing commercial light-water reactors, or weapons-grade plutonium could be isotopically separated from high-assay plutonium in existing spent fuel from light-water reactors. However, conversion of spent commercial reactor fuel into weapons-grade plutonium is currently prohibited by law [Atomic Energy Act of 1954, as amended, 42 USC section 2077(e)]. The legislative removal of this prohibition is not considered a reasonable alternative to the restart of L-Reactor as a source of weapons-grade plutonium. This policy determination was passed by Congress in December 1982 which reaffirmed the position of strict separation of nuclear defense and commercial activities established by the Atomic Energy Act in 1954.

BY-2

2.1.2 Partial-production options

The partial-production options would provide only a portion of the required defense nuclear materials if L-Reactor either was not restarted or was delayed beyond its current schedule for restart. These partial production options include increasing the power of N-Reactor at the Hanford Reservation and/or the operating SRP reactors; production of less-than-6-percent plutonium-240 at N-Reactor and/or less-than-3-percent plutonium-240 at operating SRP reactors for blending with fuel-grade plutonium; and the accelerated use of the Mark-15 lattice at the operating SRP reactors.

2.1.2.1 Increased power in operating reactors

A possible production option to the restart of L-Reactor that would partially attain the needed levels of defense nuclear materials would be to increase the power of N-Reactor at Hanford and/or the three operating reactors at the Savannah River Plant.

SRP reactors

An increase in power levels (on the order of 15 percent per reactor) and production might be achievable in SRP reactors. These reactor power gains could be achieved by installing larger heat exchangers in the reactor buildings to increase heat transfer, by increasing primary (D₂O) and secondary (H₂O) coolant flows, and by increasing reactor-blanket-gas pressure. Such changes would require rebuilding the reactor hydraulic systems (Macafee, 1983a).

Although rebuilding the hydraulic systems to increase reactor power is feasible from an engineering standpoint, increased power might not be feasible from a safety standpoint. Whereas safety considerations for the current scope of operations are well defined, safety and operation beyond the range of

experience would have to be proven. The following areas would have to be evaluated and show positive results for the more extreme operating conditions to be viable:

- The ability of the reactor safety systems and confinement system to cope with postulated accidents at increased power
- The capability of reactor piping system components to withstand increased cooling and process water flows
- The reliability of reactor components at higher temperatures and pressures

If proven feasible, the necessary modifications to increase power in the SRP reactors would take about 5 years to implement. In addition, during modifications, an estimated 1 year of reactor operating time would be required to modify each reactor for operation of the higher power level; this lost production time would also affect the blending initiative because there would be a reduced amount of 3-percent plutonium-240 for blending.

Because of the large uncertainty of this option, coupled with the length of time for implementation, safety concerns, and loss of near-term production, increasing the power of SRP reactors is not a reasonable production option to the restart of L-Reactor.

N-Reactor at Hanford

TC | The power level of the N-Reactor (currently operating at 4000 megawatts-thermal) at the Hanford Reservation could potentially be increased by 10 percent. The net annual plutonium production increase would be less than 10 percent over current levels because of production inefficiencies from increased charge/discharge of fuel and because of the downtime required to make plant modifications. The power level increase could be accomplished by increasing reactor coolant flow rates and/or temperature levels. The additional heat produced by N-Reactor would be discharged to the Columbia River through steam dump condensers.

Increased N-Reactor power levels might be feasible from an engineering design perspective. Minor improvements to the reactor instrumentation, confinement, emergency core cooling, and auxiliary systems would be required to provide the necessary operational latitude at the higher power level. Even though N-Reactor has operated as high as 4800 megawatts-thermal during a plutonium/tritium coproduction mode of operation in 1966 and 1967, the increased flow rates and temperature would be beyond the safety limits developed for current operating conditions. Before N-Reactor could be operated at the higher power level, the following safety considerations would require further evaluation to ensure satisfactory results:

- The ability of the safety systems to cope successfully with postulated accidents at elevated temperature and flow rate conditions
- The ability of critical system components to operate reliably at increased temperature and flow rates

- The ability of reactor fuel design to withstand postulated accidents at increased power levels

In addition to these considerations, the service life of N-Reactor is governed by distortion of the graphite moderator, which is directly proportional to the integrated neutron exposure to the graphite and to the graphite temperature. Because of these radiation-induced effects in the graphite moderator, the life of N-Reactor at the present power level is not expected to extend beyond the mid-1990s. Increasing the power level would decrease the service life of N-Reactor; a 10-percent power increase would reduce the expected reactor service life by about 1 year.

Environmental data, calculations, and analysis show no significant adverse radiological impacts from current or projected future operation of N-Reactor and its Fuel Fabrication Facility. Current environmental impacts of the operation of N-Reactor and its Fuel Fabrication Facility are due primarily to airborne radiological releases, radiological and chemical releases to the soil, and thermal impacts of cooling water. The calculated, whole-body population dose received by the approximately 340,000 people living within an 80-kilometer radius during 1982 was 4 person-rem from N-Reactor and the Fuel Fabrication operation. This was less than 0.012 percent of the doses due to naturally occurring radiation in the environment (PNL, 1983). TC

On the average, about 200 curies of radionuclides (almost entirely tritium) are released annually to the Columbia River near N-Reactor. A few chemical effluents are also discharged to the N-Reactor and Fuel Fabrication area soils. Those chemicals make up a minor part of the process water discharged to the ground and are either entrained in the soil column or discharged to the Columbia River in compliance with an NPDES Permit. TC

The remaining waste heat is dissipated to the environment directly in cooling water discharged to the Columbia River. N-Reactor steam is exported to the Washington Public Power Supply System generating plant, where the residual heat is discharged to the river. At 4000 megawatts-thermal, approximately 700 megawatts-thermal are discharged through a 260-centimeter outfall line to the center of the river. TC

To achieve a 10-percent increase in the power level of N-Reactor, an increase of about 10 percent in the cooling-water flow would be necessary. In past studies, however, impingement of aquatic organisms at the N-Reactor intake structure has been very low, so the increased cooling-water flow rate would result in negligible additional entrainment and impingement of aquatic organisms. The thermal discharge to the Columbia River from the discharge of cooling water would also be increased. The dominant environmental impact of a 10-percent increase in reactor power would be an increase in the thermal discharge to the Columbia River. Other impacts would include increased chemical emissions from the Fuel Fabrication Facility. Nonradioactive and radioactive releases to the environment would be expected to be increased slightly over existing release levels, but would be well within applicable control limits. TC

DOE policy is to keep N-Reactor operating as long as possible because it is the nation's only backup to the Savannah River Plant for the production of defense nuclear material.

2.1.2.2 Decreased plutonium-240 content

Another production option that would partially attain the production levels of L-Reactor would be to further reduce the plutonium-240 content of plutonium produced in existing reactors. This would allow a more rapid conversion of fuel-grade plutonium into weapons-grade material through blending. The decrease in plutonium-240 content could be achieved by the production of less-than-3-percent plutonium-240 at SRP operating reactors or less-than-6-percent plutonium-240 at N-Reactor at Hanford.

Plutonium-240 content is an undesirable product created through neutron capture of plutonium-239; its production is directly proportional to the plutonium-239 produced in the target material and the exposure time during reactor operation. A lower percentage plutonium-240 content in the plutonium product can be achieved by shortening the reactor exposure cycles. This necessitates shutting down the reactor more frequently for changing out target and/or fuel elements. However, shutting down the reactors more frequently increases reactor down time and reduces the overall amount of plutonium product that can be produced on an annual basis.

Production of less-than-3-percent plutonium-240 at SRP

The production of less-than-3-percent (2-percent) plutonium-240 at the SRP reactors is not effective in increasing production due to the excessively high throughput and increased reactor downtime. The loss of production due to reactor downtime is not compensated by the production of less-than-3-percent plutonium and blending. Therefore, this is not considered a reasonable production option to the restart of L-Reactor.

Production of less-than-6-percent plutonium-240 at N-Reactor

The production of less-than-6-percent (5-percent) plutonium-240 at the Hanford Reservation's N-Reactor can be accomplished with the current fuel design by shortening the reactor fuel cycles and/or by increasing the number of fuel assemblies discharged per cycle (ERDA, 1977).

The incremental environmental effects that would be expected from the production of less-than-6-percent plutonium-240 at the N-Reactor include those associated with increased manufacturing operations at the Hanford fuel fabrication facility. The production of the additional fuel assemblies for production of less-than-6-percent plutonium-240 would result in an approximate 20-percent increase in radiological and nonradiological releases to the environment from that facility. These releases include airborne uranium emissions from the cut-off saw exhaust, NO_x releases from the chemical bay stack, and process chemicals discharged to the 300-Area process trenches and the 183-H solar evaporation basin. Although the quantities of these materials discharged annually would increase, the average effluent concentrations during operation would remain the same.

The production of less-than-6-percent plutonium-240 would result in additional fuel processing at the Hanford PUREX reprocessing facility. There would be an increase in the radiological and nonradiological releases to the environment of approximately 2 percent per year, depending on the backlog of material processed at PUREX. The releases would include some gaseous fission products (krypton-85, carbon-14, iodine-129, and tritium), oxides of nitrogen, and tritiated water. The quantities of materials discharged annually would increase slightly; however, the average effluent concentrations during operation would remain the same. All releases from the N-Reactor fuel manufacturing facility and the PUREX operation are expected to be within applicable control limits.

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2.1.2.3 Accelerated use of Mark-15 fuel lattice

Currently, SRP reactors use the Mark 16-31 lattice for plutonium production. A Mark-15 lattice design has been developed for the SRP reactors to increase the efficiency of plutonium production. A demonstration of the Mark-15 lattice design was performed in August and September of 1983 to verify its design and operability. Similar, although less efficient, uniform lattices have been used in earlier SRP reactor operations.

Once funding is appropriated for the Mark-15 lattice, the front end of this fuel cycle must be established. This includes obtaining slightly enriched uranium from DOE gaseous diffusion plants, converting the slightly enriched uranium to uranium billets, and fabricating the billets into the Mark-15 lattice at the SRP. Presently, the materials for the Mark 16-31 lattice (highly enriched uranium and natural uranium) are obtained from available inventories.

BL-21

The conversion from the Mark 16-31 lattice to the Mark-15 lattice is presently planned for funding in FY 1985 and for implementation in late 1986. Under an accelerated program, a supplemental FY 1984 appropriation could be requested of Congress for implementation in early 1986. If promptly enacted, this would accelerate the use of Mark-15 lattice by about 6 months.

BL-21

The environmental effects of using the Mark-15 fuel lattice design are expected to be similar to those from current operations. Emissions of nitrogen oxide (NO_x) from the fuel manufacturing area are expected to increase by an estimated 12 tons annually, increasing NO_x emissions from the fuel manufacturing area operations by 50 percent and increasing annual SRP NO_x emissions by 0.24 percent. The site boundary concentrations of NO_x would be well below the ambient air quality standard (Sires, 1983).

Cooling-water discharges from the reactor areas are expected to increase Savannah River temperatures by less than 0.2°C from that due to current operations. Negligible increases in fission product gas releases, atmospheric tritium releases, and carbon-14 releases will occur resulting in 0.1-percent, 1-percent, and 0.4-percent increases, respectively, in current offsite doses. The volume of liquid radioactive effluents released to the F-Area seepage basin is expected to double, but would not exceed seepage basin capacity. The H-Area seepage basin would not be affected. Occupational exposures associated with the

TE | use of Mark-15 lattices are expected to remain the same as those for the current lattice design (Sires, 1983).

2.1.2.4 Combinations of partial-production options

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The partial-production options that could be considered for implementation include the production of less-than-6-percent plutonium-240 at the Hanford Reservation's N-Reactor, increased power at the N-Reactor, and the accelerated use of the Mark-15 lattice at operating SRP reactors. Various combinations of these three partial-production options have been evaluated with respect to their total capabilities to produce the required defense nuclear materials. Due to the throughput limitations in the fuel fabrication facility at Hanford, the production of less-than-6-percent plutonium-240 and increased power at the N-Reactor are mutually exclusive. The production of less-than-6-percent plutonium-240 would produce greater quantities of material than increased power at the N-Reactor; therefore, the potential combination of partial-production options providing the greatest material production would be the accelerated use of the Mark-15 lattice at the SRP reactors and the production of less-than-6-percent plutonium at the N-Reactor. None of these options, or combinations of options, can provide the needed defense nuclear materials requirements nor can they fully compensate for the loss of this material that would be produced by L-Reactor.

2.1.3 Delayed L-Reactor operation

If implementation of a mitigative measure, as discussed in Section 4.4, requires a delay in the scheduled restart of L-Reactor, the potential combination of two partial options could be considered (i.e., the accelerated use of the Mark-15 lattice at SRP operating reactors and the production of less-than-6-percent plutonium-240 at the Hanford Reservation's N-Reactor). The immediate enactment by Congress of an FY 1984 supplemental appropriation would be required to permit the acceleration of the use of the Mark-15 lattice in the SRP operating reactors. The accelerated use of the Mark-15 lattice, in combination with the production of 5-percent plutonium-240 at N-Reactor, would not, however, provide the amount of needed defense nuclear materials that could be produced by L-Reactor.

2.2 PROPOSED ACTION--RESTART OF L-REACTOR

The only available alternative that would satisfy the need for defense nuclear materials established in the FY 1984-89 NWSM is the resumption of L-Reactor operation as soon as practicable. L-Reactor operated from 1954 until 1968, when a decreasing demand for special nuclear materials resulted in its being placed in standby status. It has now been upgraded and restored to be

physically ready to resume operation. Operations would use the same techniques used by the three reactors (C, K, and P) currently in operation at the Savannah River Plant. Effluent control, environmental protection improvements, and safety improvements that have been incorporated into the other operating SRP reactors since 1968 have been included during the upgrade of L-Reactor.

2.2.1 SRP process description

L-Reactor would be part of an integrated SRP complex for the production of defense nuclear materials, including a fuel and target fabrication plant, five reactors (three currently operating), two chemical separations plants, a heavy-water production plant (on standby except for rework), and waste-storage facilities. This complex includes fabrication of fuel and target materials into elements and assemblies for loading into the reactors; irradiation in the reactors; separation of transuranic elements, tritium, and residual uranium from waste byproducts; heavy-water recovery and purification; and waste processing and storage. The Defense Waste Processing Facility (DWPF), now under construction, will immobilize high-level wastes currently stored in underground tanks.

The SRP fabrication plant manufactures fuel and target elements to be irradiated in the production reactors. Currently, its major products are extruded enriched-uranium, aluminum-clad fuel; aluminum-clad depleted-uranium metal targets; and lithium-aluminum control rods and targets.

Each reactor building houses one production reactor and its supporting operational and safety systems. The reactor buildings incorporate heavy concrete shielding to protect personnel from radiation and a confinement system to minimize atmospheric radioactivity releases. The reactors use heavy water (D_2O) as a neutron moderator and as a recirculating primary coolant to remove the heat generated by the nuclear fission process. The recirculating D_2O coolant is, in turn, cooled in heat exchangers by water pumped from the Savannah River and Par Pond, a 10.7-square-kilometer impoundment. Figure 2-1 shows the reactor process system. The reactors produce plutonium by the absorption of neutrons in the uranium-238 isotope. Rechargeable fuel and target assemblies all are clad with aluminum. These fuel and target assemblies are discharged from the reactors after a specified exposure period and stored in a water-filled disassembly basin to permit decay of short-lived radiation products.

The chemical separations plants dissolve the irradiated fuel and target materials in nitric acid. A solvent extraction process then yields (1) solutions of plutonium, uranium, or neptunium and (2) a high-heat liquid waste, containing the nonvolatile fission products. After the product solutions are decontaminated sufficiently from the fission products, further processing is performed in unshielded areas, where plutonium is converted from solution to solid form for shipment.

Heavy water for use as the reactor moderator was separated from river water at the heavy-water facility (now in standby except for rework) by a hydrogen sulfide extraction process and then purified by distillation.

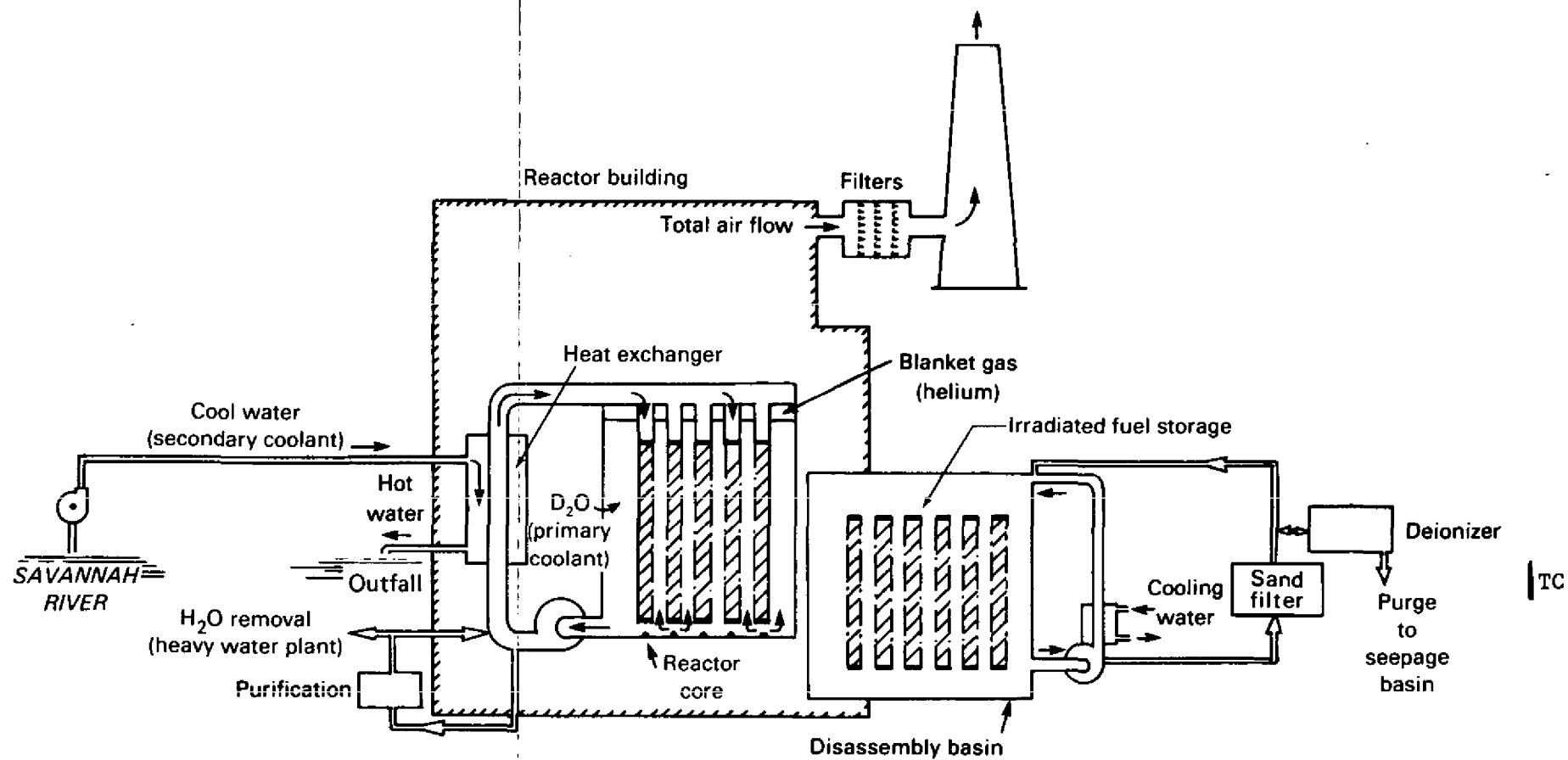


Figure 2-1. Reactor process systems.

The liquid radioactive wastes produced from the chemical processing of irradiated fuel and targets are partially concentrated and stored in large underground tanks. The DWPF will immobilize the wastes from these tanks in borosilicate glass disposal forms (DOE, 1982). These solidified wastes will be stored onsite until their final disposal in a Federal repository, which is scheduled to be available in 1998 (cf: Nuclear Waste Policy Act of 1982). Low-level radioactive solid wastes produced at Savannah River Plant are disposed of in a centrally located burial ground.

The proposed restart of L-Reactor will increase the production rate at the fuel and target fabrication facility and at the chemical separations facilities by about one-third. These facilities originally were designed to support five reactors; with the restart of L-Reactor, four reactors will be operating. Thus, the L-Reactor restart is not expected to cause major operational changes in these facilities. Operation of the DWPF by 1990 will eliminate the need for new waste tanks to accommodate the liquid waste generated from the processing of nuclear material as a result of L-Reactor operations.

2.2.2 L-Reactor description

2.2.2.1 Site

L-Reactor is located on a 0.33-square-kilometer controlled area, about 5 kilometers south of SRP's geographical center, and about 9 kilometers northwest of the closest SRP boundary. The site, an upland area between Steel Creek and Pen Branch, has a level to gently rolling topography and is about 76 meters above mean sea level. The facilities closest to L-Reactor include K- and P-Reactors, which are approximately 4 kilometers to the west and 5 kilometers east-northeast, respectively.

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2.2.2.2 Schedule

Upgrading and restoration of L-Reactor has been completed. Testing of all reactor systems has been ongoing as work on each system is completed. The reactor has been charged with heavy-water moderator and fuel and target assemblies. Testing with a full flow of cooling water will be performed for approximately 1 week before restart.

| TC

2.2.2.3 Operating work force

In anticipation of L-Reactor operation, about 350 people have been hired for training in reactor operation and maintenance. These people will be assigned throughout the SRP labor force so L-Reactor and the other reactors will be operated primarily by experienced personnel. All reactor operators and supervisors are specially trained and formally qualified.

2.2.2.4 Buildings

Figure 2-2 shows the location of the major structures in L-Area, which include the following:

- 105-L building. Houses the reactor and associated support systems; a fuel and target receiving, assembly, testing, and storage area; a pool for the storage and disassembly of irradiated fuel and target elements; and facilities for the purification of heavy-water moderator/coolant.
- 186-L basin. Receives and stores heat-exchanger cooling water pumped from the Savannah River. Has a 95-million-liter capacity.
- 190-million-liter basin. Contains a 1.9-million-liter tank and collects cooling water discharged in the event of an accident.
- Office and shop buildings.
- Other support facilities. Includes two transformer yards, sanitary treatment facility, water treatment plant, radiological health protection, and security areas.

2.2.2.5 Reactor systems

Reactor vessel and reactor lattice

The L-Reactor vessel is a cylinder about 4.5 meters high and 5 meters in diameter made of 1/2-inch Type 304 stainless steel plate. Coolant enters through six nozzles at the top of the reactor into a plenum, flows down coolant channels in the fuel and target assemblies, and discharges into the bulk moderator. It leaves through six nozzles at the bottom of the reactor vessel (Figure 2-3). A gas plenum and top radiation shield are located under the inlet water plenum. Under the reactor vessel, a radiation shield containing 600 monitor pins provides flow and temperature monitoring for each fuel and target position. The vessel is surrounded by a 50-centimeter-thick water-filled thermal shield, and a 1.5-meter-thick concrete biological shield (Du Pont, 1982).

CU-3 | Ward et al. (1980) studied the effects of neutron irradiation on the stainless-steel SRP reactor vessels and concluded that the vessels have experienced no significant deleterious effects. Furthermore, no deleterious metallurgical effects are expected in the future because neutron fluence has been accumulating very slowly since operations with lithium-blanketed charges began in 1968.

The reactor contains positions for 600 fuel and target assemblies; other principal positions in the reactor lattice are used for control rod housings, spargers, and gas port pressure-relief tubes. Interspersed among the principal lattice positions are 162 secondary positions, which can be occupied by safety and/or instrument rods. In addition to the downflow coolant for the fuel and target, upflow coolant is provided for the control assemblies and for the bulk moderator.

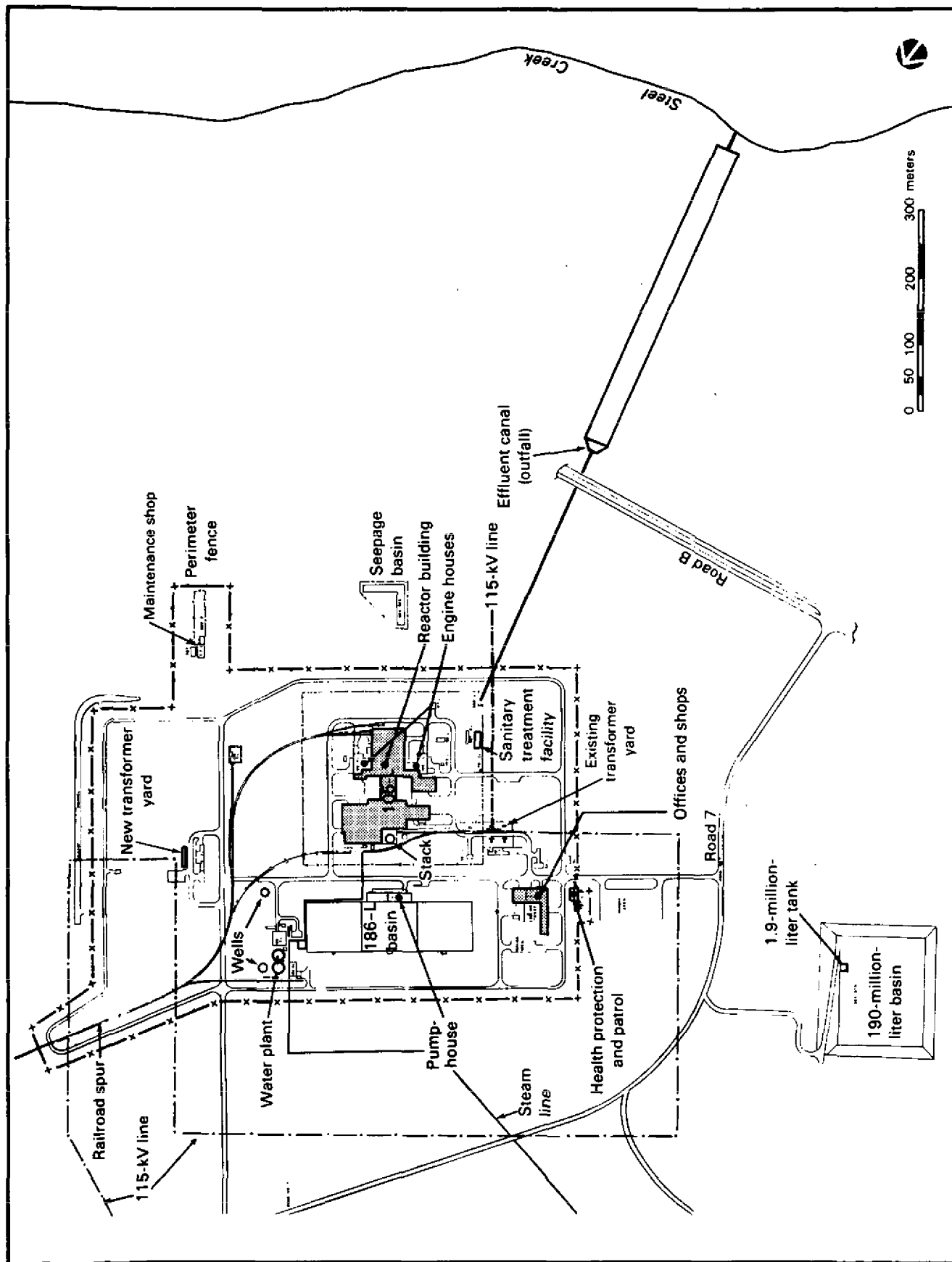


Figure 2-2. Major L-Area structures.

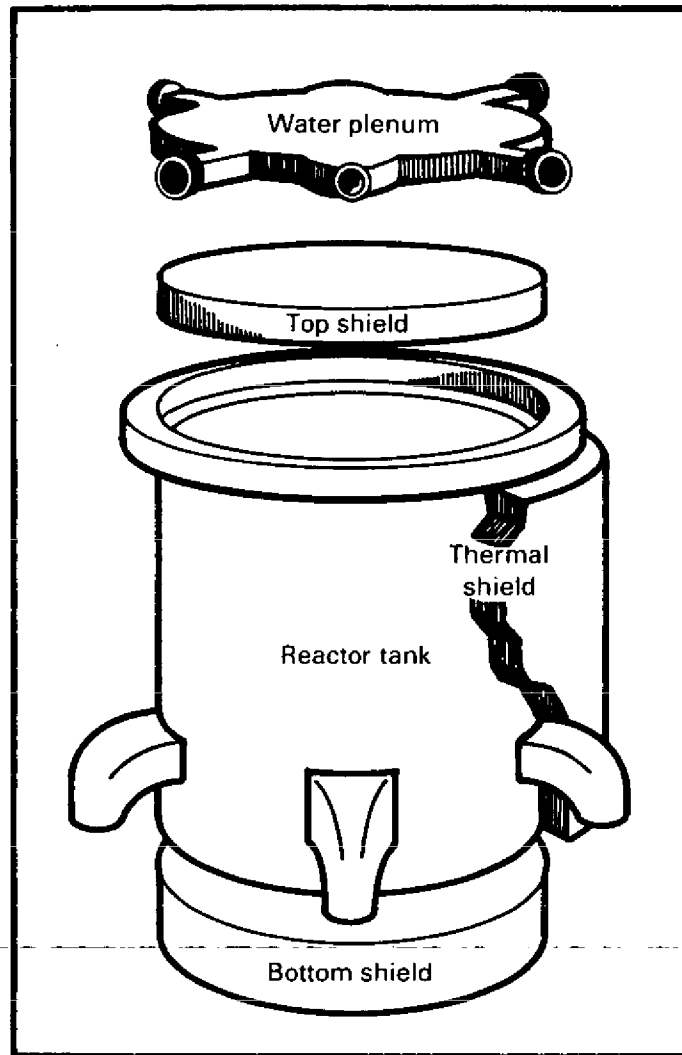


Figure 2-3. Schematic of reactor structure.

Neutron flux in the reactor is controlled by neutron-absorbing rods in 61 positions; each position contains seven individually motor-driven control rods. These control rods can be moved in gangs (groups) for simultaneous positioning, or individually in sequence. Two half-length rods in each position control the vertical flux distribution; full-length rods control overall power and the radial flux distribution.

Process monitoring and reactor control is accomplished from a central control room. The reactor can be controlled manually by an operator or automatically by an online computer.

Table 2-1 lists average values of the operating parameters for a typical L-Reactor charge.

Table 2-1. Typical L-Reactor operating parameters

Parameters	Value
Lattice--Mark 16-31	
Fuel	Enriched uranium
Target	Depleted uranium
Power	2350 megawatts thermal
Primary coolant	
Fuel temperature	113°C
Target temperature	85°C - 110°C
Coolant flow	8780 liters/second
Pressure	34,000 pascals gauge (5 psig)
Secondary coolant	
Outlet temperature	Up to 80°C
Coolant flow	11 m ³ /second

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Primary coolant system

Heavy water (D₂O) serves as both a neutron moderator and primary coolant to remove heat from the nuclear fission process. The heavy water is circulated through the reactor by six parallel pumping systems. In each system, about 1600 liters per second are pumped from one of six outlet nozzles at the bottom of the reactor, through two parallel heat exchangers, and into one of six inlet nozzles in the water plenum above the reactor. All components of the D₂O system, except the pump seals, are made of stainless steel. The L-Reactor produces no electric power, which allows it to operate without the high temperatures and pressures needed in power reactors.

Each of the six circulating systems contains a double-suction, double-volute centrifugal pump rated at 1600 liters per second at a total pressure head of 128 meters of water. Each circulating pump is driven by a 2500-kilowatt, squirrel-cage alternating-current (a.c.) induction motor drawing 125 amperes at full load. Pumps and motors are separated into groups of three in two pump rooms and two motor rooms. Each motor also drives a 2.7-metric-ton flywheel that stores enough energy to continue pumping heavy water for about 4 minutes if

there is a loss of a.c. power. Power for the a.c. motors is supplied from either of two substations.

Backup pumping capacity for heavy-water circulation is provided by six direct-current (d.c.) motors; they are normally online when the a.c. motors are operating. If a.c. power fails, each d.c. motor will drive a pump to provide about 25 percent of the normal flow, enough to remove residual heat from the shutdown reactor. Each d.c. motor is connected directly to its own online diesel generator; two generators are kept in reserve.

Limits on pD (the heavy-water equivalent of pH), conductivity, and impurity levels of the heavy water are maintained to control the corrosion of aluminum and stainless steel and to reduce the decomposition of the heavy water. Sustained reactor operations at Savannah River Plant have demonstrated that the corrosion rate of aluminum components and the associated problems of high radioactivity and turbidity in the process systems can be reduced substantially by controlling pD. To minimize aluminum corrosion, nitric acid is added to the heavy water through a pump suction line to maintain a heavy-water pD of about 5.2. Because some of the acid is neutralized as the process water flows through the purification deionizers (causing the pD to increase), periodic injections of nitric acid are necessary.

Secondary coolant system

Each of the six heavy-water pumping systems contains two parallel, single-pass heat exchangers to transfer heat from the heavy water (primary coolant) to secondary cooling water drawn from the Savannah River and discharged to Steel Creek, where it flows back to the Savannah River. Water is taken from the Savannah River at two pumphouses and delivered to the L-Area cooling-water reservoir (186-Basin) with flows at approximately 11 cubic meters per second. An alternate tie-line provides an emergency supply of cooling water from the river to the reservoir if the primary line from the river fails. Without a supply of water from the river, the reservoir can cool the reactor in the shutdown mode for 1 to 2 weeks by recirculation.

A pumphouse adjacent to the reservoir delivers water to the reactor building. If pumphouse power is lost, the options available to deliver water to the reactor building include (1) gravity flow from the reservoir through the pumphouse, (2) gravity flow from the reservoir to the emergency pumps in the reactor building via a bypass line, (3) forced flow from the river pumphouses using a pipeline that bypasses the reservoir and delivers cooling water directly to the reactor building, (4) recirculation of reservoir water with the emergency pumps, and (5) recirculation of disassembly-basin water with the emergency pumps.

The effluent cooling water flows from the reactor building to the effluent sump. As much as 0.70 cubic meters per second can be recirculated. Normally, the water overflows a weir in this sump and flows to Steel Creek.

Core reloading

New fuel is received and stored in the reactor assembly area. Racks and hangers maintain adequate spacing for criticality control; an additional safety

margin for assemblies containing fuel is provided by storage in racks constructed of material that contains boron, a neutron absorber. Moderating materials are strictly controlled in the assembly area to prevent criticality. Procedural controls limit the type and amount of material in process at any time.

The equipment for core reloading includes an inlet conveyor, a charge machine, a discharge machine, and a deposit-and-exit conveyor. The charge and discharge machines are similar, and each can perform most of the functions of the other; however, only the discharge machine can provide heavy- or light-water cooling to an irradiated assembly. Both machines travel on tracks on two parallel ledges that are part of the reactor-room wall; power for their operation is provided through cables along the ledges.

Reloading operations are conducted from a control room adjacent to the reactor control room. The charge and discharge machines can be operated manually or automatically via an automatic tape-control system. Graphic displays on the control console track the location and operation of the machines.

Fuel discharge and storage

Fuel and target assemblies are discharged from the reactor by the discharge machine. Four sources of water are available on the discharge machine to cool an assembly during the discharge operation--primary D₂O, primary H₂O, secondary D₂O, and secondary H₂O. The primary and secondary sources supply water through different paths to the assembly. Cooling starts automatically when an irradiated assembly is completely withdrawn from the reactor; it can also be maintained if an assembly sticks during withdrawal.

For each type of assembly, an upper limit is specified for heat-generation rate at the time of discharge; discharge of an assembly does not start until the heat-generation rate of the assembly has decayed to this upper limit.

The deposit-and-exit conveyor, located in a water-filled canal connecting the reactor room and the disassembly basin, receives an assembly from the discharge machine and carries it under the reactor room wall to a water-filled disassembly basin for temporary storage.

Irradiated assemblies are stored in the disassembly basin to allow radio-nuclides and heat to decay to a level low enough for shipment to the separations facilities. The assemblies are cooled by natural convection; hangers allow this cooling while maintaining adequate spacing for criticality control. The basin water also provides shielding of radiation from the assemblies. Procedural controls and instrumentation prevent shipment of insufficiently cooled assemblies.

Blanket-gas system

The blanket-gas system, which uses helium (an inert gas), is the initial barrier to the release of radioactive gases from the reactor. This system has three primary functions: (1) to dilute deuterium and oxygen evolved from the moderator (due to radiolysis) to a nonflammable concentration, (2) to recombine the deuterium and oxygen constituents of the gases evolved to heavy water, and (3) to maintain the pressure in the moderator (pressurize the gas plenum of the reactor to about 34,000 pascals gauge (5 psig) and thus increase the heavy-water

saturation temperature). Helium is used as the blanket gas because it neither reacts with moderator decomposition products nor absorbs neutrons to produce radioactive gases.

During operation, gases evolve from the reactor and enter the gas plenum. From the plenum, the gases are routed to catalytic recombiners and spray separators where the deuterium and oxygen are recombined and most of the entrained heavy water is removed from the helium and returned to the reactor. The helium is then returned to the gas plenum.

Activity-confinement system

During reactor operation, the process areas are maintained at a pressure lower than the pressure of the external atmosphere to ensure that all air from the process areas is exhausted through the activity-confinement system (Du Pont, 1982). As shown in Figure 2-4, the air from these areas is exhausted through a set of confinement filters before it is released to the 61-meter stack.

Three large centrifugal fans exhaust the air from the process areas. Two of these fans normally are online, but only one is necessary to maintain the negative pressure. Fan motors can be powered by two electric sources:

1. Normal building power, from at least two substations
2. Emergency building power, from diesel generators

In addition, each has a backup motor; the backup motors for any two of the fans can be powered simultaneously by automatically starting diesel generators.

Exhaust filters remove moisture, particulates, and halogens. The filter banks are enclosed in five separate compartments, three to five of which are online during operation. Each compartment can be isolated for maintenance and/or testing; each contains filter banks, in the following order of air-flow treatment:

1. Moisture separators--designed to remove about 99 percent of entrained water--(spherical-particles-measuring 1 to 5 microns) to protect against significant blinding of the particulate filters.
2. Particulate filters--designed to retain more than 99 percent of all particulates with diameters of 0.3 micron or larger.
3. Activated carbon beds--impregnated carbon designed to retain halogen activity.

Liquid-radwaste system

The chemical purity of the moderator is maintained to minimize heavy-water radiolysis and to minimize the corrosion rate of aluminum and stainless steel in the reactor; in addition, moderator impurities absorb neutrons that otherwise would be utilized in the production of nuclear materials. The neutron activation of moderator impurities and corrosion products, along with any fission products released by fuel failures, contributes to the overall activity level in the moderator.

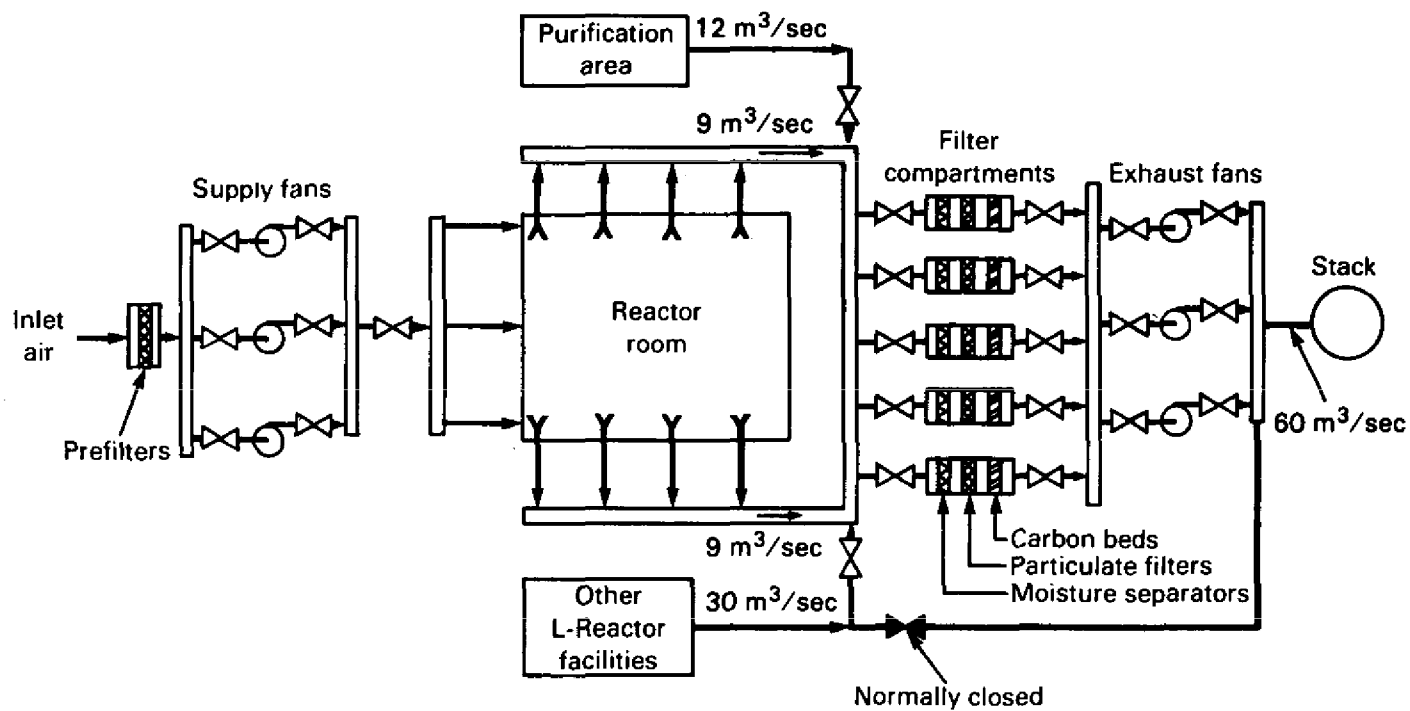


Figure 2-4. Reactor confinement system.

The moderator is continuously purified by circulation of a side stream to a purification area to be deionized and filtered. Most of this side stream is returned to the reactor; a small amount is distilled to remove light water (H_2O).

The purification system circulates about 1.9 liters per second through a pre-filter, a deionizer, and an after-filter. The deionizer contains deuterized cation and anion exchange resin. The filters retain particles larger than 10 microns in diameter.

The filters and deionizers are located in a shielded cell area. Radioactive impurities are concentrated in disposable filter and deionizer units. Vessels containing spent deionizer are remotely loaded into heavily shielded casks for transport to a facility for the eventual recovery of deuterium oxide. After processing, these vessels are sent to the burial ground for disposal.

Part of the reactor side stream is diverted to the distillation area for removal of light water.

An evaporator system removes particulate matter from deuterium oxide from the distillation column reboiler purge. No facilities are currently available to remove tritium from the reactor moderator. When the deuterium oxide distillation columns are emptied for maintenance or repair, the water is either collected in a tank to be reused or drummed to be reworked at the heavy-water production plant.

Target and spent-fuel assemblies removed from the reactor are rinsed in the discharge machine. The rinse water is collected by the discharge machine-water pan and sent to the 2270-liter rinse collection tank. Rinse water is drummed and reworked.

Some radioactivity is transferred from the irradiated assemblies to the water in the disassembly basin, even after rinsing. Periodic purging of the basin water is necessary to reduce the radiation exposure to operating personnel from the accumulation of tritium. During the purging operation, water from the basin is passed through two deionizer beds in series, and monitored before it is discharged to a low-level radioactive seepage basin. This process reduces the release of any radioactivity other than tritium to the seepage basin. The spent resin from the deionizer beds is regenerated in the chemical separations areas, and the spent regenerant is concentrated and stored in high-level radioactive waste tanks in the separations areas.

Two sand filters maintain the clarity of the disassembly-basin water. Particulate matter in the basin water tends to agglomerate and adsorb radioisotopes. When the basin water passes through the sand filters, the particulate burden is reduced. The filtration rate can vary from 32 to 95 liters per second, depending on the initial fluid clarity and the demand for treatment. When the differential pressure across the filter beds indicates the need, a filter can be isolated and backflushed. Backflushed radioactive material is transferred to the chemical separations area for concentration and storage in high-level radioactive waste tanks.

Solid radwaste

Contamination from induced activity accounts for most low-level solid waste. Work clothing, plastic sheeting, and kraft paper also become contaminated when they are used for occupational protection. Such material comprises most of the low-level waste; irreparable valves, pipe sections, pumps, instruments, and aluminum and stainless-steel reactor components also constitute such waste. Solid waste is packaged for disposal in the SRP burial ground.

2.2.2.6 Reactor shutdown systems

L-Reactor will have the same defenses against reactivity transients that other SRP reactors have. These defenses include flow and temperature sensors for each fuel assembly, which are monitored by redundant computers. The computers will rapidly detect any reactivity transient that might begin and will cause the normal control rod system to insert to safely terminate the transient--the first line of defense. If the control rod system fails to terminate the transient, the computers will activate the safety rod drop system that will shut down the reactor within about 1 second--the second line of defense. If the safety rods do not rapidly shut down the reactor, the computers will automatically activate the injection of liquid "poison" into the reactor moderator/coolant to accomplish the same safe shutdown--the third line of defense.

Scram systems

Scram circuits monitor reactor operating variables and will cause safety and control rods to be inserted into the reactor if abnormal conditions exist. The scram instruments for a particular variable (e.g., neutron flux, coolant pressure) are set to produce a scram at the operating limit imposed for safe operation. A reactor scram at the setpoint will prevent damage to the fuel, the reactor, or the confinement system.

Supplementary safety system

The supplementary safety system (SSS) is fully independent, acting as a backup shutdown system. The SSS can be actuated manually; it is actuated automatically if safety rods fail to shut down the reactor. When the system is activated, gadolinium nitrate, an efficient neutron absorber, is injected into the moderator. The SSS is designed such that the reactor can be maintained in a subcritical mode even if all safety and control rods are in the fully withdrawn condition. The system has redundant tanks, piping, and valves.

Automatic backup shutdown-safety computer (ABS-S/C).

The ABS-S/C actuates the SSS if safety rods fail to shut down the reactor quickly following a scram signal. It uses logic programmed into the two redundant safety computers. The ABS-S/C should prevent damage to the reactor structure for all postulated transients.

Automatic backup shutdown-gang temperature monitor

The gang temperature monitor (GTM) automatically actuates the SSS if temperatures in selected monitored positions exceed prescribed limits.

2.2.2.7 Engineered safety systems

Emergency cooling system (ECS)

The ECS removes decay heat following a reactor shutdown by adding light water directly to the reactor core if heavy-water coolant or circulation is lost. Four sources of light water are available; two have to be online for full-power reactor operation:

1. A diesel-driven booster pump that supplies H₂O from the 95-million-liter 186-L basin
2. A 107-centimeter diameter header pressurized by five pumps drawing H₂O from the 95-million-liter basin
3. An additional 107-centimeter header pressurized by five pumps
4. A pipeline from the river pumphouse direct to the reactor, pressurized by the river water pumps

The ECS can be actuated manually, or automatically by falling liquid levels in the reactor tank. When the ECS is actuated, the diesel-driven booster pump starts, and valves are automatically opened or closed to couple the reactor system with the primary sources of light water. If the booster pump does not start, the other sources of emergency cooling are sufficient to cool the reactor.

Water removal and storage

If the heavy-water system ruptures, heavy and light emergency cooling water would flow to sump pumps in the basement of the reactor building. Water from the sump is pumped first to a 225,000-liter underground tank; the flow then goes to a 1.9-million-liter tank in the 190-million-liter emergency earthen basin. Some of the water on the 0-foot-level process room floor would drain directly to the 1.9-million-liter tank. If this tank should become full, the additional water would flow into the emergency basin. The 1.9-million-liter tank is vented to the activity confinement system in the reactor building.

Remote control station

A remote control station for all four reactors, located 18 kilometers from L-Area, is manned full time. The station is a data display and control facility for reactors; it can provide remote control of reactor cooling and activity confinement systems for a shutdown reactor if the control room in the reactor building cannot be occupied.

The Power Department operators who normally work in the remote control station are trained to perform routine data acquisition tasks, to check abnormal condition indications, and, in certain circumstances, to initiate incident action and request staffing of the station by Reactor Department supervisors. These supervisors perform all other control actions after they staff the station.

Data and control signals are transmitted through underground electrical cables that link the remote control station with each reactor area.

Approximately 90 indications of the status of equipment (such as on, off, open, and closed) are displayed on the remote control station panel for each reactor area. Any change of equipment status will cause an audible alarm and a flashing light to indicate the piece of equipment involved. These alarms are divided into categories that indicate the severity or importance of the event. Category I and II alarms indicate that a reactor incident either exists or is possible. All other alarms fall under Category III. In addition to the status-of-equipment indications, the values of approximately 50 process variables can be displayed on the remote control station panel for each reactor area.

If the remote control station receives a Category I or II alarm, the Power Department operator attempts to communicate with the reactor control room personnel in the affected area; if the operator cannot establish communication, he or she executes an "enable" control function for remote control operation. This action causes visible and audible signals in the reactor control room to alert the operators there that an enable function has been requested. The reactor operating crew then must execute a "disable" function; if this is not done, the enable function is granted automatically and remote control capability is established. If the Power Department operator in the remote control station observes the indication that the enable function has been granted, he or she trips the incident switch and requests staffing of the remote control station with Reactor Department supervisors by communicating with the unaffected reactor areas. The reactor operator takes immediate actions to place the reactor in a safe condition before the transfer of control to the remote control station. The Power Department operator then begins recording data that will be useful in analyzing the incident situation. The operator follows written procedures for all these actions.

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When Reactor Department supervisors arrive at the remote control station, they examine the data, alarm indications, etc., and then follow procedures to analyze and control the incident (e.g., increase fuel cooling, minimize D₂O leakage, minimize pump and motor room flooding, adjust ventilation dampers) to minimize any activity release from the reactor building and reactor area.

Power Department operators also report Category III alarms and any other situation that is abnormal to the affected area. They also routinely display and record process data to ensure the operability of the systems. Functional checks of key equipment are made periodically to ensure the operability of the remote control equipment.

2.2.2.8 Support systems

Electric power

Normal supply. Electric power from the SRP power grid is supplied to the L-Area by two independent 115-kilovolt transmission lines. In the event of a power failure, a supervisory control cable running along these lines enables the power dispatcher to monitor and switch equipment on the plant grid. Three 30,000-kilovolt-ampere transformers in the L-Area are connected to the 115-kilovolt grid. Each transformer can carry the L-Area load.

Emergency supply. Two 1000-kilowatt a.c. generators supply emergency power to the reactor building. Eight 103-kilowatt d.c. generators supply power to the process pump motors that maintain the heavy-water cooling flow to the reactor if the normal a.c. power fails; normally, six of these generators are operated at all times, and the remaining two are on standby. Four other diesel generators are located throughout the L-Area to provide backup power for ventilation fans, lights, and other equipment. Reactor shutdown systems, including scram circuits, safety and control rod drives, and the Supplementary Safety System, are also backed up by online batteries.

Steam

Steam is supplied to the L-Reactor facility for process service and ventilation heat. An interarea pipeline supplies steam from the K-Area powerhouse.

Potable water

Potable water is supplied to the L-Area from two deepwells producing from the Tuscaloosa Formation. This is also the source for clarified service water, filtered water, and domestic and fire-control water. The water is processed in a treatment plant before use.

Sanitary sewage

Sanitary sewage is processed by a secondary treatment plant using an extended aeration-activated sludge process. The plant is large enough to meet the demands placed on it during normal operations by the L-Area workforce. Chlorinated discharges from the treatment plant are sent to the process sewer, which discharges to Steel Creek. Sludge from the treatment plant is trucked to an existing sludge pit near the Central Shops area.

2.2.3 Process and effluent monitoring

All gaseous radioactive releases through the L-Area stack are monitored continuously. Stack effluent tritium is monitored by two ion chambers in parallel flowpaths. A continuous sampling technique with daily quantitative analysis is also used. All other air and water samples are monitored routinely and quantitative release records are kept. An above-normal activity level is investigated to locate the source so the condition can be corrected. The secondary cooling water discharged from the reactor heat exchangers is monitored continuously to detect any radioactivity leakage from the primary coolant.

Nonradiological samples are collected in accordance with the National Pollutant Discharge Elimination System (NPDES) permit (Section 6.2.1).

2.3 NO-ACTION ALTERNATIVE

L-Reactor has been maintained on standby since 1968. The no-action alternative is defined as the continued maintenance of the L-Reactor facility in the current ready-for-operation standby mode, which includes testing of flows as high as 6.1 cubic meters per second (the maximum flow recorded prior to June 28, 1983). This is consistent with the restarting definition given in the Energy and Water Development Appropriations Act, 1984:

For purposes of this paragraph the term "restarting" shall mean any activity related to the operation of the L-Reactor that would achieve criticality, generate fission products within the reactor, discharge cooling water from nuclear operations directly or indirectly into Steel Creek, or result in cooling system testing discharges which exceed the volume, frequency and duration of test discharges conducted prior to June 28, 1983.

If L-Reactor is to be maintained in this standby mode, any improvements made to the other SRP reactors will also be made to L-Reactor. The adoption of this alternative would not meet the established need for nuclear material for national defense purposes described in Appendix A (classified). The no-action alternative, therefore, is not responsive to the Presidential mandate.

Maintaining L-Reactor in a standby mode would have the following environmental impacts (Turcotte, Palmiotto, and Mackey, 1983):

- Water would be withdrawn from the Savannah River on a periodic basis for hydraulic testing and flushing of cooling systems.
- Nonthermal effluents would be discharged to the Savannah River via Steel Creek during hydraulic testing and flushing.
- Sanitary wastes from the secondary treatment facility would be discharged to Steel Creek.
- Nonradiological atmospheric emissions would continue as present from the K-Area power plant to supply L-Area with steam.
- Unsalvageable domestic trash would be disposed of in the SRP landfill.
- The L-Reactor workforce would be maintained at the ready-for-operation standby mode (approximately 100 people).

2.4 SUMMARY OF ALTERNATIVES*

This section summarizes the L-Reactor alternatives and the mitigation alternatives considered in Chapter 4 of this EIS.

2.4.1 Mitigation alternatives

Section 4.4 describes the L-Reactor mitigation alternatives for safety systems, cooling water, disassembly-basin water disposal, and 186-basin sludge removal.

2.4.1.1 Safety system alternatives

L-Reactor, like the other SRP operating reactors, is equipped with a confinement system to treat radioactive releases due to routine operation and potential accident situations. Alternative systems to further reduce such releases, especially during accident situations, were evaluated and compared, as listed in Table 2-2. Due to the expected low risk of L-Reactor operation, the high cost/benefit ratio, and the long lead time for the installation of alternatives, DOE has identified the existing confinement system as its preferred safety system alternative.

2.4.1.2 Cooling-water alternatives

Thirty-three alternative cooling water systems are evaluated in Section 4.4.2. These alternatives can be grouped into five major categories--once-through cooling lake, recirculating cooling lake, once-through cooling tower, recirculating cooling tower, and direct discharge. This section summarizes the engineering and environmental evaluations for the most favorable alternative for each of these categories. This approach enables the reader to evaluate and compare a range of reasonable alternatives, thus defining the issues and providing a clear basis for choice among alternatives. The criteria used in selecting the most representative alternatives are the ability to meet South Carolina water-quality standards, production considerations, schedule, environmental factors, and cost. The ability to expedite the schedule was also considered for these alternatives, as was the degree that reactor operation must be modified to meet State of South Carolina water-quality standards.

Table 2-3 compares engineering and environmental factors for the five alternative cooling-water systems (i.e., once-through 1000-acre lake, recirculating 1300-acre lake, once-through 2.8°C approach temperature cooling tower, a recirculating 2.8°C approach temperature cooling tower with treatment of blowdown, and direct discharge). While the cooling tower would cause fewer

*Because Section 2.4 is new, it does not require vertical change bars.

Table 2-2. Comparison of safety system alternatives (primarily confinement/containment options)

System	Technical feasibility	Estimated costs (\$MM) ^a			Benefit person-rem averted ^d (3% melt)	Cost/benefit ^e (\$ per person-rem averted)	Timing (months to complete)
		Capital ^b	Production Loss ^c	Total			
Existing confinement system	Demonstrated and proven	Installed	None	Installed	--	Reference	Installed
Remote storage system	Not demonstrated	250	25	275	445	620,000	24
Low temperature adsorption system	Not demonstrated	90	50	140	460	300,000	36
Tall stack	Demonstrated	50	15	65	175	370,000	15
Internal containment	Questionable	250	150	400	455	880,000	48
Leaktight dome	Questionable	850	50	900	450	2,000,000	36

^aMM - millions of dollars.

^bRough estimates escalated to 3Q FY 1988 construction midpoint.

^cRough cost of production lost during construction at \$150,000 per reactor-day.

^dAssumes hypothetical accident (3-percent melt) occurs. Dose within 80-kilometer radius from reactor (2500 megawatts accident). 50 percent meteorology. Benefit = (dose with existing confinement system - dose with alternative system) = person-rem averted.

^eThe expected cost/benefit considering the probability of the accident is at least one million times greater than the values listed here.

Table 2-3. Comparison of cooling-water alternatives

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Schedule for implementation	36-month construction schedule could be accelerated to complete lake in one construction season (6 months).	40-month construction schedule could be accelerated to complete lake, but would take longer (two construction seasons, i.e., about 18 months) than 1000-acre due to construction of recirculating system, road relocation, and additional embankments.	27-month construction schedule might be accelerated to complete the cooling tower in slightly more than 1 year.	27-month construction schedule; cannot be accelerated because of long-lead-time procurement of pumps.	Would not require any additional time for implementation.
Preliminary cost capital (million \$)	25	73	50-55	75	0
Operating (million \$/year)	3.4	2.9	5.5	3.2	3.4
Thermal compliance	Would meet South Carolina water-quality standards with changes in operating power levels.	Would meet South Carolina water-quality standards with changes in operating power levels.	Would meet South Carolina 32.2°C standard but variance would be required from ΔT of 2.8°C requirement.	Would meet South Carolina water-quality standards.	Would require reclassification of Steel Creek to be permissible.

Table 2-3. Comparison of cooling-water alternatives (continued)

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Modification to operation	Power reduction would be necessary between late spring and early fall to maintain balanced biological community in lake. Average annual 14% power reduction. Amenable to installation of precoolers (~\$10M capital) that would allow an increase in power efficiency.	4% inherent operating power loss. Greater than 14% power loss to maintain a balanced biological community.	Operating power of 100%; infrequent periods (once in 4.5 years) might require some reductions.	Higher temperature of recirculating cooling water would cause a reduction in operating power levels; averages 6.5% power reduction.	Operating power of 100%.
<u>Environmental Factors</u>					
Thermal effects	Balanced biological community in the lake. Steel Creek corridor, delta, and Savannah River swamp protected from thermal effects downstream from embankment.	Same as for once-through 1000-acre lake.	Steel Creek corridor, delta, and Savannah River swamp protected from thermal effects.	No effects expected.	Steel Creek corridor, delta, and Savannah River swamp to be thermally impacted. Zone of passage to remain in the Savannah River. Also, there is a serious thermal shock effect.

Table 2-3. Comparison of cooling-water alternatives (continued)

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Discharge flow effects	11 cubic meters per second to be discharged. Flow will impact downstream wetlands and will cause increased streambank erosion and delta growth below embankment.	About 0.5 cubic meter per second to be discharged below embankment. Erosion and wetland impacts downstream of embankment very small.	11.0 cubic meters per second. Erosion and delta growth would be greater than the 1000-acre lake due to erosion over longer reach of Steel Creek.	About 0.6 cubic meter per second; erosion and wetlands impacts downstream of embankment very small.	11 cubic meters per second to be discharged. Flow will impact downstream wetlands and will cause increased streambank erosion and delta growth below embankment.
Habitat impacts	735 to 1015 acres of wetlands would be affected by inundation or flow effects. 775 acres of uplands inundated.	240 acres of wetlands and 1060 acres of uplands would be inundated.	635 to 915 acres of wetlands would be affected by inundation and flow effects.	Slight impacts to wetlands.	Direct discharge will eliminate between 730 to 1000 acres of wetlands in the Steel Creek corridor, delta, and Savannah River swamp.
Water withdrawal	About 11 cubic meters to be withdrawn from the Savannah River.	About 1.8 cubic meters per second to be withdrawn from the Savannah River.	Same as 1000-acre once-through lake.	About 1.4 cubic meters per second to be withdrawn from the Savannah River.	Same as 1000-acre once-through lake.
Entrainment/impingement	Water withdrawal will cause impingement of an additional 16 fish per day and entrainment of 3 to 6% of fish eggs and larvae passing SRP intakes.	Water withdrawal will cause impingement of less than 3 fish per day and entrainment of 0.5 to 2% of fish eggs and larvae passing SRP intakes.	Same as 1000-acre once-through lake.	Slightly less than recirculating cooling lake.	Same as 1000-acre once-through lake.

Table 2-3. Comparison of cooling-water alternatives (continued)

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Endangered species	Habitat for American alligator and wood stork to be affected. Consultations with U.S. Fish and Wildlife Service in progress.	Habitat for American alligator affected; foraging habitat for wood stork not affected.	Same as 1000-acre once-through lake.	No impacts to endangered species.	Same as 1000-acre once-through lake.
Radiocesium remobilization	Radiocesium releases primarily related to flow. Maximum release to be no more than 4.4 curies in first year. Release within applicable standards.	Radiocesium releases would be smaller due to reduction in the amount of water discharged. Maximum release would be about 0.8 curie in the first year.	Radiocesium release would be smaller than for 1000-acre once-through lake and direct discharge. Maximum release would be 3.3 curies in the first year.	Same as 1300-acre recirculating cooling lake.	Radiocesium releases due to both hot water and flow effects. Maximum release to be about 4.4 curies in first year. Release within applicable standards.
Archeological sites	Four sites would be protected by monitoring and mitigation. One site to be flooded; recovery plan approved. Further surveys identified 10 potentially significant sites; mitigative measures to be taken as appropriate.	Same as 1000-acre once-through lake.	Five sites would be protected by monitoring and mitigation.	No archeological sites would be impacted.	Same as once-through cooling towers.

environmental effects, the Department of Energy has identified the once-through 1000-acre lake as its preferred cooling-water alternative, because it would:

1. Meet all State and Federal regulatory and environmental requirements, eliminating thermal impacts on the river, swamp, and unpounded stream, while providing a productive balanced biological community in the lake
2. Provide the earliest reactor startup and the maximum plutonium deliveries of any environmentally acceptable cooling-water alternative that would meet regulatory requirements
3. Have the lowest costs of any environmentally acceptable cooling-water alternative that would meet regulatory requirements
4. Be amenable to backfitting with precooler systems, if needed, which could improve reactor operational flexibility and the production capability

The 1000-acre lake's expected environmental effects were bracketed by the cooling-water alternatives analyzed in the Draft EIS (i.e., a once-through 500-acre lake, a 1300-acre recirculating lake, and modified reactor power operation).

2.4.1.3 Disposal of disassembly-basin purge water

The disassembly-basin water is treated by ion exchange and sand filter/clarifier systems to remove radionuclides and to maintain water clarity. The disassembly-basin water is purged periodically to maintain an acceptable tritium concentration in the room air so the occupational exposure can be kept as low as reasonably achievable. The amounts of tritium entering the atmosphere and liquid pathways as a result of (1) discharge to the seepage basin, (2) discharge to Steel Creek, and (3) evaporation are listed in Table 2-4. These releases are predicted to occur after the tenth year of L-Reactor operation. During the first year, about one-tenth of these amounts will be released. Small amounts of radionuclides other than tritium will also be released to Steel Creek due to disassembly-basin purges.

Table 2-5 lists offsite doses from tritium and other radionuclides. Doses to the maximum individual from seepage-basin disposal are about half of those from a direct discharge to Steel Creek and twice those expected from the use of an evaporator. Estimated population doses from an evaporator are slightly lower than those from either discharge to the seepage basin or a direct discharge to Steel Creek. However, these differences are small.

There is little difference in cost between a discharge to the seepage basin and a direct discharge to Steel Creek; the cost of either method is small. Considering only operating costs, the cost-benefit ratio for installing an evaporator system is \$42,000 per person-rem avoided in the offsite population doses; this is a costly alternative. The cost-benefit ratio for detritiation of the moderator is even greater per person-rem avoided (Section 4.4.5). Thus, DOE selected discharge to the seepage basin as its preferred alternative; at the

Table 2-4. Tritium releases from disassembly-basin water disposal alternatives--tenth year.

Release pathway	Tritium releases (Ci)		
	With seepage basin	Direct to Steel Creek	Evaporation
Atmosphere	3,200	--	11,000
Steel Creek	6,000	11,000	--

Table 2-5. Offsite doses from disassembly-basin water disposal alternatives--tenth year

Exposure pathway	With seepage basin	Direct to Steel Creek	Evaporator
MAXIMUM INDIVIDUAL (CHILD) DOSE (mrem/yr)			
Atmosphere ^a	0.013	--	0.044
Liquid ^b	<u>0.074</u>	<u>0.15</u>	<u>--</u>
Total	0.087	0.15	0.044
POPULATION DOSE (person-rem/yr)			
Atmosphere ^a			
80-kilometer radius	0.5	--	1.9
Liquid ^b	<u>8.6</u>	<u>15.9</u>	<u>--</u>
Total	9.1	15.9	1.9

^aTritium only released by atmospheric pathway.

^bRadionuclides other than tritium also enter liquid exposure pathway.

same time, research and development activities for detritiation are continuing for a potential general application at the Savannah River Plant.

2.4.1.4 186-Basin sludge disposal

Savannah River water is held in a 95-million-liter reservoir (186-basin) before it passes through the L-Reactor heat exchangers. Suspended solids contained in the river water settle out in the 186-basin and require removal to minimize the growth of the Asiatic clam, Corbicula, and blockage effects on the reactor heat exchangers. Four alternatives were considered for removal of the sludge: (1) batch discharge to Steel Creek, (2) land application, (3) borrow pit application, (4) continuous sediment suspension.

None of the alternatives would have an impact on L-Reactor restart following a scheduled extended shutdown. The "batch discharge to Steel Creek" and "continuous sediment suspension" alternatives would have no land use requirements, but could contribute to delta growth in the Savannah River swamp or filling of the cooling lake. The "borrow pit application" alternative would be limited to the number and capacity of retired borrow pits on the SRP.

The "batch discharge to Steel Creek" alternative would not require funds for construction activities; the other three alternatives would require funds for construction, equipment procurement, maintenance, and additional operating expenses. Thus, DOE has selected the batch discharge to Steel Creek as its preferred alternative. Batch discharge is presently allowed by the National Pollutant Discharge Elimination System (NPDES) permit issued to SRP by the South Carolina Department of Health and Environmental Control. This permit requires the conduct of a 1-year study to determine the potential environmental effects of batch discharge.

2.4.2 L-Reactor alternatives

TC | The proposed action is to resume L-Reactor operation as soon as practicable to produce needed defense material (i.e., plutonium). No reasonable full production options have been identified to the restart of L-Reactor. In addition, no partial-production options or combination of options have been identified that can provide the needed defense nuclear materials requirements or that can fully compensate for the loss of the material that would be produced by L-Reactor. The Department of Energy's preferred alternative is to operate L-Reactor after the construction of a 1000-acre lake to cool the reactor thermal discharges to meet the water-quality standards of the State of South Carolina. The Department of Energy has changed the preferred alternative it presented in the Draft EIS (i.e., to operate L-Reactor with direct discharge to Steel Creek with subsequent mitigation) due to public comments and discussions with the South Carolina Department of Health and Environmental Control.

Table 2-6 compares the impacts for the preferred alternative, as described in Chapter 4, and those for the no-action alternative. The no-action alternative would not satisfy the established needs for defense nuclear materials.

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative

Impact	Preferred Alternative ^a	No Action ^b
Cost	Increased capital costs of \$25 million. Operating costs would be 3.4 million per year for the 1000-acre lake.	Direct costs of \$10-12 million per year for maintenance. There would be no operating costs.
Fuel fabrication	Less than 33% increase in throughput, emissions, and effluents.	No change from present operations.
Chemical processing	Less than 33% increase in throughput, emissions, and effluents.	No change from present operations.
Waste management	Less than 33% increase in amount of waste processed and stored; operation of the DWPF by 1990 will eliminate need for new waste tanks to accommodate the liquid waste generated from the processing of nuclear material as a result of L-Reactor operation.	No change from present operations.
Land use and socioeconomics	An additional 1000 acres for the lake plus additional land during construction to support earthmoving and other construction activities. SRP workforce about 350 for L-Reactor; additional 550 temporary construction workers.	No additional land would be required; standby workforce of about 100 will be required; approximately 330 jobs would be lost.
Archeological sites	Four sites eligible for inclusion in the <u>National Register</u> might be affected; a resource recovery plan has been developed by the University of South Carolina Institute of Archeology and Anthropology for one historic site (38 BR 288), located within the proposed lake area. This mitigation plan has been approved by the SHPO and ACHP, which concurred that this plan will result in no adverse impacts to <u>National Register</u> properties. No sites considered eligible for the <u>National Register</u> have been located in association with embankment construction; archeologic studies in the lake area are continuing. It is expected that some significant sites associated with the Ashely Plantation might be found that will be in the lake.	Some erosion impacts are anticipated from cold-flow testing to the eligible sites.

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Cooling-water system withdrawal	L-Reactor will withdraw about 11 cubic meters per second, or about 4% of the average annual flow rate and 7% of the 7-day, 10-year low flow of the Savannah River. Withdrawal will cause impingement of an additional 16 fish per day, and entrainment of about 3 to 6% of all fish eggs and larvae passing the SRP intakes when L-Reactor is operating under average conditions.	Testing and flushing of secondary cooling-water system approximately several days per month at flows up to 6.2 cubic meters per second; impingement and entrainment impacts during these test periods will be about one-half the impacts for the reference case.
Ground-water withdrawal	A total of 5.9 cubic meters per minute will be withdrawn from the Tuscaloosa aquifer for L-Reactor and the increment by its support facilities. Total ground-water withdrawal by SRP with L-Reactor operating is projected to be 7% greater than in 1982. Some ground-water recharge in surficial formations due to lake.	Ground-water withdrawal of 0.94 cubic meter per minute is required.
Ground-water quality	Ground-water quality in the Barnwell and McBean formations will be contaminated by releases from L-Reactor and its support facilities in the Separations Area (as much as a 33% increase from support facilities) to seepage basins. Contamination will flow to Steel and Four Mile Creeks. Radiological impacts are summarized in this table under "Radiation Risk to Public." Concentrations of nonradioactive contaminants in creek waters will be similar to concentrations in the Savannah River, except for lower pH and greater concentrations of nitrite and nitrate. The L-Reactor contribution to the M-Area seepage basin is expected to be 33% of the total (current) discharge. The ground-water remedial action project will be initiated in August 1984 with a capacity of three times the current	No release of radioactivity to the L-Reactor seepage basin, and no incremental increase in contaminants to the ground water in the Separations Area, or the M-Area.

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Ground-water quality (continued)	discharges to the basin. This project, consisting of nine recovery wells and an air stripper, will intercept seepage from the basin where it reaches the water table in 10 to 17 years. The use of seepage basins at SRP is being considered on a sitewide basis. Use of the M-Area seepage basin will be discontinued by April 1985, when the discharges will be treated by a process wastewater-treatment plant.	
Air quality	Operational emissions would consist primarily of NO _x , SO _x , and particulate matter. L-Area power house was dismantled during standby period. Emissions from K-Area would increase by 10% to supply steam to L-Reactor. Some fugitive dust emissions during construction of embankment. No detectable impact on local or regional air quality is expected.	No change from present operations. No detectable impact on air quality would be expected.
Solid waste	All unsalvageable domestic trash would be packaged and disposed of in SRP landfill. Sanitary waste sludge would be disposed of at the SRP sludge pit. Bottom ash sluiced to the K-Area ash basin would increase by 10%.	No change from present operations (i.e., amounts of less than 10% of hose for L-Reactor operation would be disposed of in SRP landfill; sanitary waste sludge would be disposed of at the SRP sludge pit).
Thermal discharge to Steel Creek	L-Reactor will discharge about 11 cubic meters per second of cooling water to the 1000-acre lake. Fluctuating reactor power will assure a balanced biological community in the lake (i.e., maintain 32.2°C or less for about 50 percent of the lake). Conditions in Steel Creek below the embankment would not present any adverse impacts concerning access to, and the spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta, except perhaps in winter, when the water	No thermal discharges to Steel Creek; however, minor impacts during periods of testing would occur due to flooding and siltation.

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Thermal discharge to Steel Creek (continued)	temperatures would be 7° to 9°C above ambient. These warmer temperatures could concentrate fish at the mouth of Steel Creek. Reactor shutdowns during the winter would result in gradual heat loss in this area, which would minimize any cold shock effects. Projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp, and the mouth of Steel Creek would be within about 1°C of ambient. The 1000 acres inundated by the lake will include 225 acres of wetland and 775 acres of upland. The flow rate would adversely impact 215 to 335 acres of wetland in the Savannah River swamp that provide foraging habitat for mallard and wood duck. The embankment and cooling lake would prevent access by riverine and anadromous fish to about 100 acres of wetlands along Steel Creek above L-Reactor. However, the only migratory fish in this reach of Steel Creek would be the American eel, which can access the lake. Access to Meyers Branch would not be affected by the lake.	
Thermal discharge to Savannah River	Average values of water temperatures at the mouth of Steel Creek are projected to be 28°C, 22°C, and 13°C during summer, spring, and winter, respectively. The 5-day, worst-case value during summer is projected to be 30°C or within about 1°C of ambient. There will be a zone of passage for the movement of fish up and down the river past SRP.	No thermal discharges to the Savannah River; therefore, no change in the present thermal plumes in the river.
Endangered species	Increased flow from the cooling lake would affect foraging habitat for the wood stork, and the habitat for the American alligator; additional habitat for alligator would be created by the lake; consultation with FWS continuing	Habitat for wood stork and American alligator could be affected intermittently during cold flow testing. No impacts to the shortnose sturgeon.

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Endangered species (continued)	for both species; no impacts to short-nose sturgeon.	
Surface-water quality	Approximately 10% increase in discharges to K-Reactor area ash basins; sanitary wastes discharges to the lake after secondary treatment; liquid effluents discharged to Savannah River via the lake would have chemical characteristics similar to those of the river.	Some continuous nonthermal low flow and periodic nonthermal high flow releases to Steel Creek; liquid effluents would be within NPDES permit requirements.
Radiation risks to public		
Routine operations	About 81,000 Ci of radioactivity, primarily tritium, would be released annually to the atmosphere from L-Reactor; about 7,900 Ci annually would be released directly and indirectly through a seepage basin and ground water flow path to surface streams and then to the Savannah River. The maximum individual dose would be about 0.60 millirem in the tenth year of operation; the dose to the population would be about 25.6 person-rem. Expected population doses would be about 0.02% of natural background.	No releases of radioactivity from L-Reactor.
Accidents	Accidents are highly unlikely; safety systems have been improved to further reduce the chance of an accident. Small additional risk due to possible embankment failure.	Extremely unlikely.
Radiocesium transport	About 4.4 Ci of radiocesium could be resuspended and transported from Steel Creek to the swamp and to the Savannah River and its floodplain 20-25% less each year thereafter. During the first year, radiocesium concentrations due to the restart of L-Reactor, after complete mixing in the river, would be about 0.5 pCi/liter, assuming average flow	Small amounts remobilized during periodic testing/flushing of secondary cooling system; maximum individual dose from this release would be 0.01 millirem per day of testing.

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

Impact	Preferred Alternative ^a	No Action ^b
Radiocesium transport (continued)	conditions. The maximum individual dose from this release is calculated to be about 3.5 millirem for the first year, decreasing to about 0.3 millirem in the tenth year of operation. Of the 4.4 Ci of radiocesium remobilized, 0.9 Ci could be deposited in a 1235-acre offsite swamp. The deposition rate will decrease to about 0.08 Ci in the tenth year.	

^aPreferred alternative--operate L-Reactor after construction of 1000-acre lake.

^bNo action--maintain L-Reactor in a ready-for-operation standby mode.

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3 AFFECTED ENVIRONMENT

This chapter describes the environment that will be affected by the resumption of L-Reactor operations. Major emphasis is placed on areas that past operations have shown to have the greatest potential for being affected. Much of this material was covered in the Environmental Assessment, L-Reactor Operation (DOE, 1982a).

3.1 GEOGRAPHY

3.1.1 Site location

The Savannah River Plant (SRP), including the L-Reactor, is located in southwestern South Carolina. The plant occupies an almost circular area of approximately 780 square kilometers, bounded on its southwestern side by the Savannah River, which is also the Georgia-South Carolina border. Figure 3-1 presents the site location in relation to major population centers, the closest being Augusta, Georgia, and Aiken and Barnwell, South Carolina.

The locations of various facilities of the Savannah River Plant are shown in Figure 3-2. The L-Reactor site is located in the south-central portion of the SRP, about 5 kilometers from South Carolina Highway 125 and 9 kilometers from the nearest plant boundary. Three small South Carolina towns, Snelling (population 111), Jackson (population 1771), and New Ellenton (population 2628), and the City of Barnwell (population 5572) lie within 25 kilometers of L-Reactor. Chem-Nuclear Systems, Inc., and the Barnwell Nuclear Fuel Plant (currently not expected to operate), which is owned by Allied-General Nuclear Services, are about 25 kilometers east of L-Reactor; the Vogtle Nuclear Power Plant is approximately 15 kilometers to the west-southwest.

3.1.2 Site description and land use

The Atomic Energy Commission, a predecessor agency to the U.S. Department of Energy (DOE), selected the location of Savannah River Plant in November 1950, after studying more than 100 potential sites. Criteria used in the selection of the site included the low population density, the accessibility of a large cooling water supply, and the low frequency of floods and destructive storms (DOE, 1980). The construction of SRP facilities began in February 1951, and eventually involved more than \$1 billion in expenditures with a peak construction force of 38,500 workers.

The Savannah River Plant is a controlled area with public access limited to through traffic on South Carolina Highway 125 (SRP Road A), U.S. Highway 278, and SRP Road 1; the Seaboard Coast Line Railroad; approved tour groups; forest management activities; controlled hunting; and environmental studies. Access to Savannah River Plant is also permitted for organized deer hunts, which began in 1965 to help control the deer population.

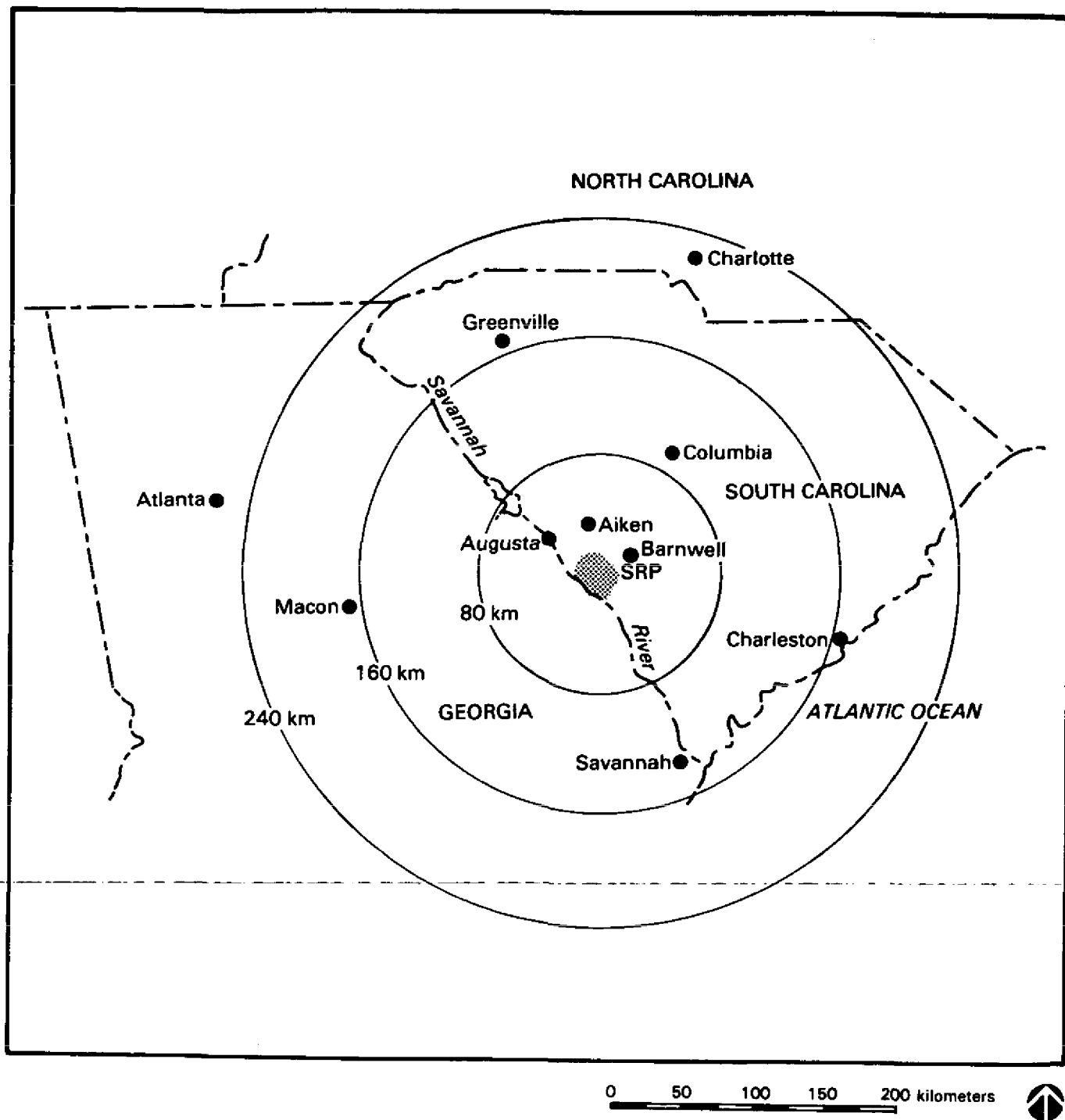
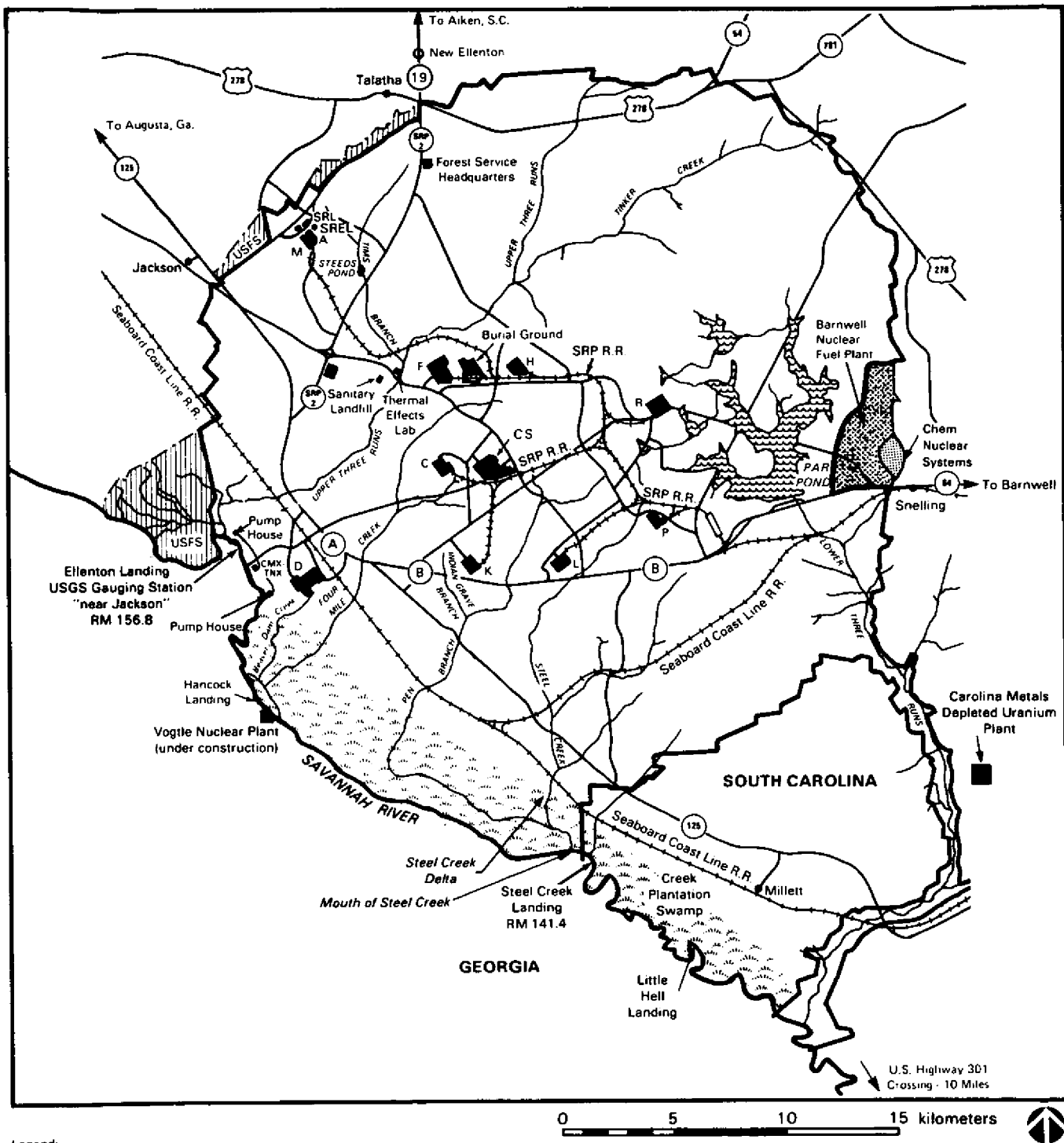


Figure 3-1. SRP location in relation to surrounding population centers.



Legend:

- C, K, R, L, P Reactor Areas (C, P, K are operating)
- F, H Separations Areas
- M Fuel and Target Fabrication
- D Heavy Water Production
- A Savannah River Laboratory and Administration Area
- CS Central Shop
- RM River Mile
- Road A = Highway 125

Figure 3-2. Savannah River Plant site.

The SRP facilities include five nuclear production reactors (three currently operating), two chemical separations areas, a fuel and target fabrication facility, a heavy-water production facility (on standby except for rework), and various supporting facilities (Figure 3-2). Onsite waste-disposal facilities include tank farms near the chemical separations areas for storage of high-level waste and a 195-acre burial ground for low-level radioactive waste. Construction is underway on the Fuel Materials Facility (F-Area) and the Defense Waste Processing Facility (north of H-Area).

The Savannah River Plant is located in the Aiken Plateau physiographic division of the Coastal Plain of South Carolina. Due to the plant's proximity to the Piedmont region, it has somewhat more relief than the near-coastal areas, with onsite elevations ranging from 27 to 104 meters above mean sea level. This area is underlain by the Tuscaloosa aquifer, which supplies well water to several operating areas of the Savannah River Plant, including L-Reactor. Par Pond is a man-made cooling impoundment; cooling water from the operating reactors is discharged either to this impoundment (P-Reactor at present and R-Reactor before it was placed on standby) or to one of the SRP streams (C-Reactor to Four Mile Creek and K-Reactor to Pen Branch at present and L-Reactor to Steel Creek before it was placed on standby), all of which drain to the Savannah River.

K- and P-Reactors are approximately 4 kilometers to the west and east-northeast of L-Reactor, respectively. C-Reactor is about 7 kilometers northwest of L-Reactor, and R-Reactor is 8 kilometers northeast of L-Reactor.

3.1.3 Historic and archeological resources

In 1982, 62 sites in the study area (Section 3.2.2) were listed in the National Register of Historic Places (see Appendix E). Richmond County had the largest number of sites (26), most of which are in the City of Augusta. Approximately 20 more National Register sites are in Aiken and Allendale Counties. Fifteen of the 62 sites are within 15 kilometers of the Savannah River Plant.

During January and February 1981, a survey was conducted of the Steel Creek terrace and floodplain system below L-Reactor for archeological resources and sites that might qualify for inclusion in the National Register of Historic Places (Hanson et al., 1982). The area of Steel Creek surveyed was 13 kilometers long and 300 meters wide. Archeologists traversed the first and second terraces of the creek system, inspecting 4-square-meter plots every 5 meters along the creek. Sites found were divided into three groups--those significant (i.e., eligible for nomination to the National Register of Historic Places), those potentially significant, and those not significant.

The survey identified 18 historic and archeological sites along Steel Creek below L-Reactor. One archeological site, located at the confluence of Steel Creek and Meyers Branch, was considered significant in terms of National Register criteria. It could yield important data on relatively uninterrupted prehistoric occupation that began in the Early Archaic Period (9500-7500 B.C.) and continued through the Mississippian Period (A.D. 1000-1700). In July 1982,

the DOE requested the concurrence of the Keeper of the National Register on this site's eligibility for nomination to the National Register. The Keeper concurred in this site's eligibility.

Seven other sites were also considered potentially significant in terms of National Register criteria. Three of these sites occur beyond the area of potential effects from increased water levels in Steel Creek due to L-Reactor operation. The remaining four sites include three mill dams that date to the early nineteenth century and an historic roadway across the Steel Creek flood-plain. In July 1982, the DOE requested the concurrence of the Keeper of the National Register regarding the eligibility of these sites for nomination to the National Register. The Keeper of the National Register concurred in the eligibility of these four sites for inclusion in the National Register. A monitoring and erosion protection plan has been implemented for all sites eligible for inclusion in the National Register. TC

The remaining 10 sites were not considered significant in terms of National Register criteria. These are archeological sites, dating possibly as far back as 6000 B.C., that are lacking in integrity or are too limited in content to permit the acquisition of additional data. They were not considered eligible for nomination to the National Register.

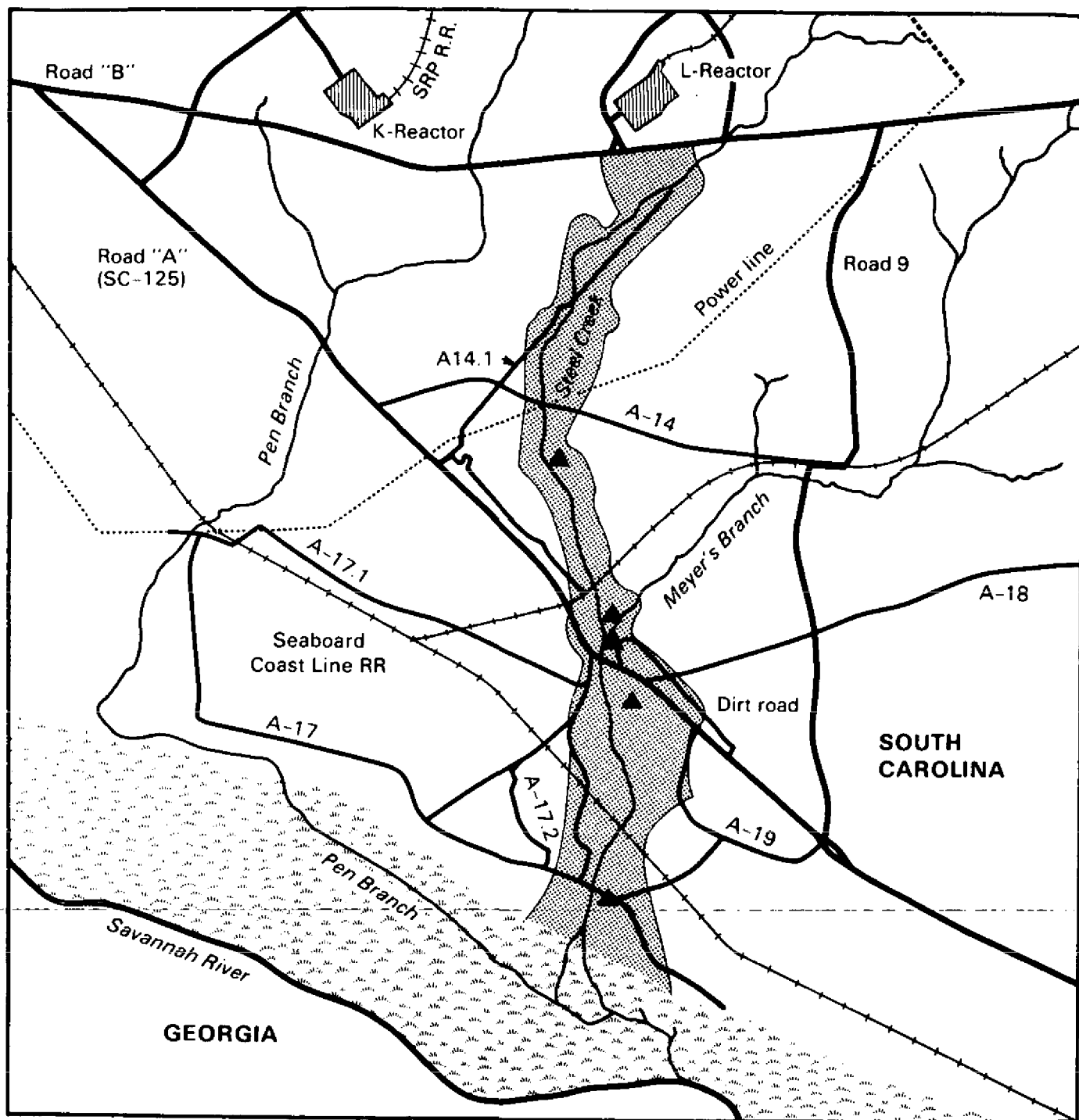
Figure 3-3 shows the location of the five sites that have been determined to be eligible for inclusion in the National Register.

In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described as of ephemeral quality and not eligible for nomination to the National Register of Historic Places.

Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation will be completed prior to restart (Hanson, 1984). TC

3.2 SOCIOECONOMIC AND COMMUNITY CHARACTERISTICS

A comprehensive characterization of socioeconomic and community characteristics around the Savannah River Plant was undertaken for the DOE in 1981. Additional information on the topics presented in this section can be found in the Socioeconomic Baseline Characterization for the Savannah River Plant Area, 1981 (ORNL, 1981) and the Final Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina (DOE, 1982b).



Legend:

-  Swamp
-  Area intensively surveyed
-  Archeological/historic sites

0 1000 2000 3000 4000 5000 meters



Figure 3-3. General map of archaeological survey area and sites listed in the *National Register of Historic Places*.

3.2.1 Past impacts of Savannah River Plant

The socioeconomic impacts of the Savannah River Plant (SRP) on the people and communities in its vicinity began with the relocation of the resident population from the SRP site and construction of the first facilities in 1951. By 1952, a peak construction workforce of 38,500 was onsite. Populations of the nearby towns increased, and the number of trailer courts and new homes increased rapidly. These early days and the changes induced by plant construction are described in In the Shadow of a Defense Plant (Chapin et al., 1954).

The primary socioeconomic impact of the Savannah River Plant since the completion of initial construction has been the large number of permanent jobs created. The permanent operating and construction force has averaged 7500, ranging from a low of 6000 in the 1960s to the current 9200 (December 1982). About 97 percent of this total are employed by E. I. du Pont de Nemours and Company and its subcontractors; the remainder are employed by the U.S. Department of Energy (221), the University of Georgia (55), and the U.S. Forest Service (22).

The greatest impact of the Savannah River Plant has been on Aiken County, especially the City of Aiken, and the small towns immediately around the SRP site, as listed in the SRP worker distribution pattern in Table 3-1. SRP workers and families comprise roughly one-half of the City of Aiken's 15,000 people and account in large measure for the high median family incomes in Aiken County.

3.2.2 Study area

Approximately 97 percent of SRP employees reside in a 13-county area surrounding the Savannah River Plant. Of these 13 counties, 9 are in South Carolina and 4 are in Georgia. The greatest percentage of employees now reside in the six-county area of Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia (Figure 3-4). Together these six counties house approximately 89 percent of the total SRP workforce. Because any new L-Reactor operating employees will reside in a distribution similar to that listed in Table 3-1, these six counties were chosen as the study area for the assessment of potential socioeconomic and community effects.

3.2.3 Demography

3.2.3.1 Study area population

Table 3-2 lists the 1980 populations in the study area for counties and places of more than 1000 persons. The largest cities in the study area are Augusta in Georgia, and Aiken, North Augusta, and Barnwell in South Carolina. Of the 31 incorporated communities in the study area, 16 have populations under 1000 persons, and 11 have populations between 1000 and 5000 persons. Aiken, Columbia, and Richmond Counties, which comprise the Augusta Standard Metropolitan Statistical Area (SMSA), have a total population of about 327,400; however,

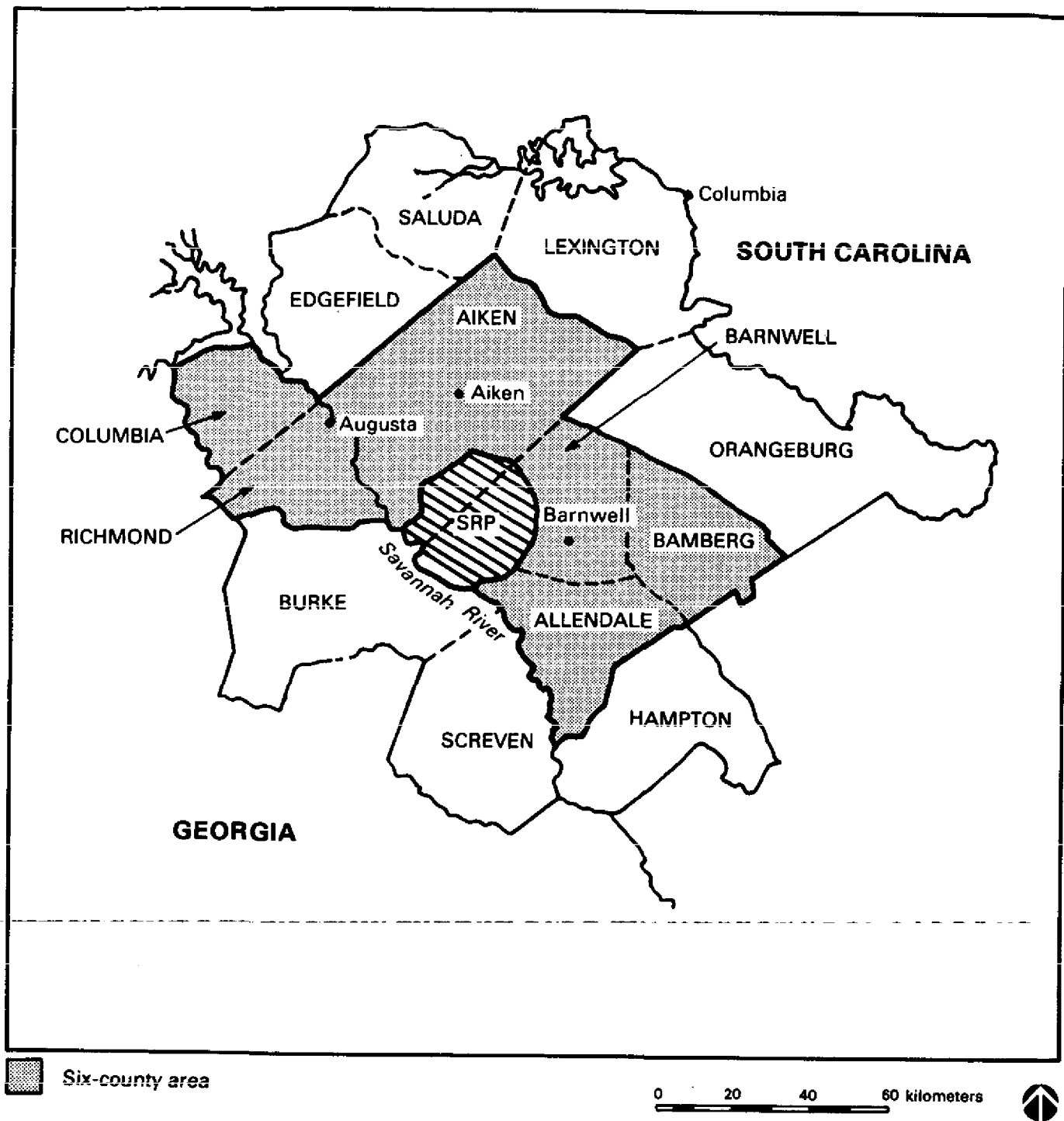


Figure 3-4. Counties in SRP area.

Table 3-1. Distribution of SRP employees
by place of residence

Location of residence	Percent of SRP labor force
South Carolina	80.0
Aiken County	58.8
Allendale County	1.8
Bamberg County	2.0
Barnwell County	8.8
Edgefield County	1.1
Hampton County	1.2
Lexington County	1.6
Orangeburg County	1.7
Saluda County	1.0
Other counties	2.0
Georgia	19.9
Columbia County	3.1
Richmond County	14.8
Burke County	0.3
Screven County	0.8
Other counties	0.9
Other states	0.1
Total	100.0

most of this population resides outside cities or towns. About two-thirds of the total six-county population resides in rural or unincorporated areas.

Over the last three decades, the rate of population growth has varied dramatically from county to county. From 1950 to 1980, the counties comprising the Augusta SMSA experienced a positive growth rate; the combined average annual rate was about 3 percent. The most significant population increases occurred in Columbia County, which experienced an average growth rate between 1960 and 1980 of about 10 percent per year. The rural counties--Allendale, Bamberg, and Barnwell--experienced population declines between 1950 and 1970; reversals of this decline occurred between 1970 and 1980 when population increases for these counties ranged from 9 to 16 percent. The population growth rate experienced in the study area during the last two decades was about equal to that experienced in the southern United States and slightly less than the growth rate experienced in the South Atlantic Region (Bureau of the Census, 1983).

Population densities in the study area ranged from a low in 1980 of 10 persons per square kilometer in Allendale County to a high of 215 persons per square kilometer in Richmond County. The 1980 average population density of about 47 persons per square kilometer for the study area is less than the 53.5 persons per square kilometer for the South Atlantic Region of the United States (Bureau of the Census, 1983).

Table 3-2. 1980 population for counties and places of 1000 persons or greater^a

Location	1980 population
Aiken County, South Carolina	105,625
City of Aiken	14,978
Town of Jackson	1,771
City of North Augusta	13,593
City of New Ellenton	2,628
Allendale County, South Carolina	10,700
Town of Allendale	4,400
Town of Fairfax	2,154
Bamberg County, South Carolina	18,118
Town of Bamberg	3,672
City of Denmark	4,434
Barnwell County, South Carolina	19,868
City of Barnwell	5,572
Town of Blackville	2,840
Town of Williston	3,173
Columbia County, Georgia	40,118
City of Grovetown	3,384
City of Harlem	1,485
Richmond County, Georgia	181,629
City of Augusta	47,532
Town of Hephzibah	1,452
Study area total	376,058

^aAdapted from the Bureau of the Census (1982a,b).

During the last 30 years, the population in the study area has tended to be slightly younger than the national average, despite a slight increase in the median age between 1970 and 1978. The birth rates in the six-county area have also tended to be somewhat higher than the national average.

3.2.3.2 Regional population

In 1980 the estimated population in the 80-kilometer area around the Savannah River Plant was approximately 563,300 persons. The year 2000 population in this area is estimated at 852,000 persons. This estimate was calculated utilizing the 1970-to-1980 growth rate of each county in the 80-kilometer area, assuming these growth rates would continue in the future. For counties that

experienced a negative population growth rate between 1970 and 1980, the calculation assumed that no continued population decline would occur. This total county population estimate for the year 2000 is approximately 12 percent higher than the estimates prepared by the States, based on a comparison with projections prepared by Georgia and South Carolina.

3.2.3.3 Transient population

The transient population within 16 kilometers of the L-Reactor consists of the SRP workforce; a total of 8864 personnel (July 1983) at the Vogtle Nuclear Power Plant, which is currently under construction; and about 300 personnel working for Chem-Nuclear Systems, Inc. The Barnwell Nuclear Fuel Plant, which is owned by Allied General Nuclear Services, is expected to maintain only a guard force.

The SRP workforce is expected to increase due to construction of the proposed Defense Waste Processing Facility and other ongoing activities. Therefore, in the mid-1980s, the SRP workforce could be near 12,600, decreasing to about 8500-9000 personnel in the mid-1990s.

Recreational hunting and camping account for about 10,000 visitor-days within a 24-kilometer radius of L-Reactor. Travelers crossing Savannah River Plant on U.S. Route 278 and South Carolina Highway 125 and on the Seaboard Coast Line Railroad add about 20,800 person-days to the 16-kilometer transient population (Du Pont, 1982a).

There are no schools, military reservations, hospitals, prisons, or airports within the 16-kilometer radius from L-Reactor.

3.2.4 Land use

In the study area near Savannah River Plant, less than 5 percent of the existing land-use pattern is devoted to urban and built-up uses. Most land uses of these types are in and around the Cities of Augusta, Georgia, and Aiken, South Carolina. Agriculture accounts for about 24 percent of total land use; forests, wetlands, water bodies, and unclassified lands that are predominantly rural account for about 70 percent of total land use.

All the counties in the study area except Allendale have zoning ordinances, and all except Bamberg have approved land-use plans. Of the land-use controls most commonly used by communities (i.e., zoning, subdivision regulations, land-use plans, building codes, and mobile home/trailer park regulations), 22 of the 31 incorporated jurisdictions in the study area have at least one type of regulation.

Less than 5 percent of the total SRP land area, including the L-Reactor site, is used by facilities engaged in the production of defense nuclear materials. Reservoirs and ponds comprise approximately 3000 acres on the SRP site. The remainder is composed of natural vegetation and pine plantations that are managed by the U.S. Forest Service under a cooperative agreement with DOE.

3.2.5 Public services and facilities

There are nine public school systems in the study area. County-wide school districts are located in each county except Bamberg, which has two districts, and Barnwell, which has three. In 1980, all school districts, except Allendale, reported available classroom space to accommodate a total of 8600 new students. The Aiken and Richmond County school districts reported the greatest capacity, with space for about 3600 and 2600 new students, respectively.

Of the 120 public water systems in the study area, 30 county and municipal systems serve about 75 percent of the population. The other 90 systems are generally smaller and serve individual subdivisions, trailer parks, or commercial and industrial enterprises. All but four of the municipal and county water systems--the Cities of Aiken, Augusta, and North Augusta, and Columbia County--obtain their water from deep wells. For those municipal and county water systems that use ground water as their supply, restrictions in system capabilities are primarily due to storage and treatment capacity rather than availability of ground water.

Most municipal and county wastewater-treatment systems have the capacity to treat additional sewage. Selected rural municipalities in Allendale, Bamberg, and Barnwell Counties and the City of Augusta in Richmond County have experienced problems in treatment-plant capacities. Programs to upgrade facilities are under way or planned in most of these areas.

3.2.6 Housing

Since 1970, the largest increases in the number of housing units have occurred in Columbia, Aiken, and Richmond Counties. Columbia County has grown the fastest, nearly doubling its number of housing units. Between 1970 and 1980, Aiken and Richmond Counties each experienced about a 36-percent increase in the number of housing units. In Aiken County, half of this increase resulted from the high growth rate in the number of mobile homes.

Vacancy rates for owner-occupied housing units for Richmond and Columbia Counties in 1980 were 4 and 3 percent, respectively, while vacancy rates for the South Carolina counties in the study area ranged from a low of 1 percent in Barnwell County to a high of 1.5 percent in Aiken County. Vacancy rates for rental units were the highest in Richmond County (15 percent), while the remaining counties ranged between 7 to 12 percent.

3.2.7 Economy

Nonfarm employment in the study area is concentrated in the manufacturing industries. Manufacturing constitutes the largest employment category in each county except Richmond County. Significant percentages of employment in retail and wholesale trade establishments also exist in Allendale and Richmond Counties.

Agriculture and agricultural employment is an important element in the economy of each county. In 1978, Allendale County had the highest average value of products sold per farm--about \$58,500--while Columbia County had the lowest average--about \$10,000.

Employment levels in the study area have increased in recent decades as both the total labor force and participation rates have increased. Per capita incomes in Aiken and Richmond Counties were the highest in the study area, and in 1974 ranked in the top 50 percent of the national averages. Most of the other counties, however, ranked in the bottom 11 percent of the national averages.

The substantial contribution of Savannah River Plant to the rise in the standard of living in the study area has been a major socioeconomic benefit. The FY 1983 operating budget is \$864 million with the FY 1984 budget expected to be about \$1.1 billion. In FY 1983, \$370 million will be paid as direct wages and salaries. Local purchases are expected to be approximately \$20 million. Of the total FY 1982 purchases of \$247 million, about \$10 million was spent with disadvantaged businesses and \$100 million was spent with small businesses.

In the six-county area, 39 local jurisdictions exercise the right to levy taxes. These jurisdictions include six counties, five school districts, and 28 cities and towns. Property taxes (real and personal) accounted for approximately 17 percent of total local revenues in 1979, while state and Federal funds accounted for 11 and 8 percent, respectively. Local expenditures on transportation and public works constituted 27 percent of total expenditures in 1979; another 21 percent was expended for public safety.

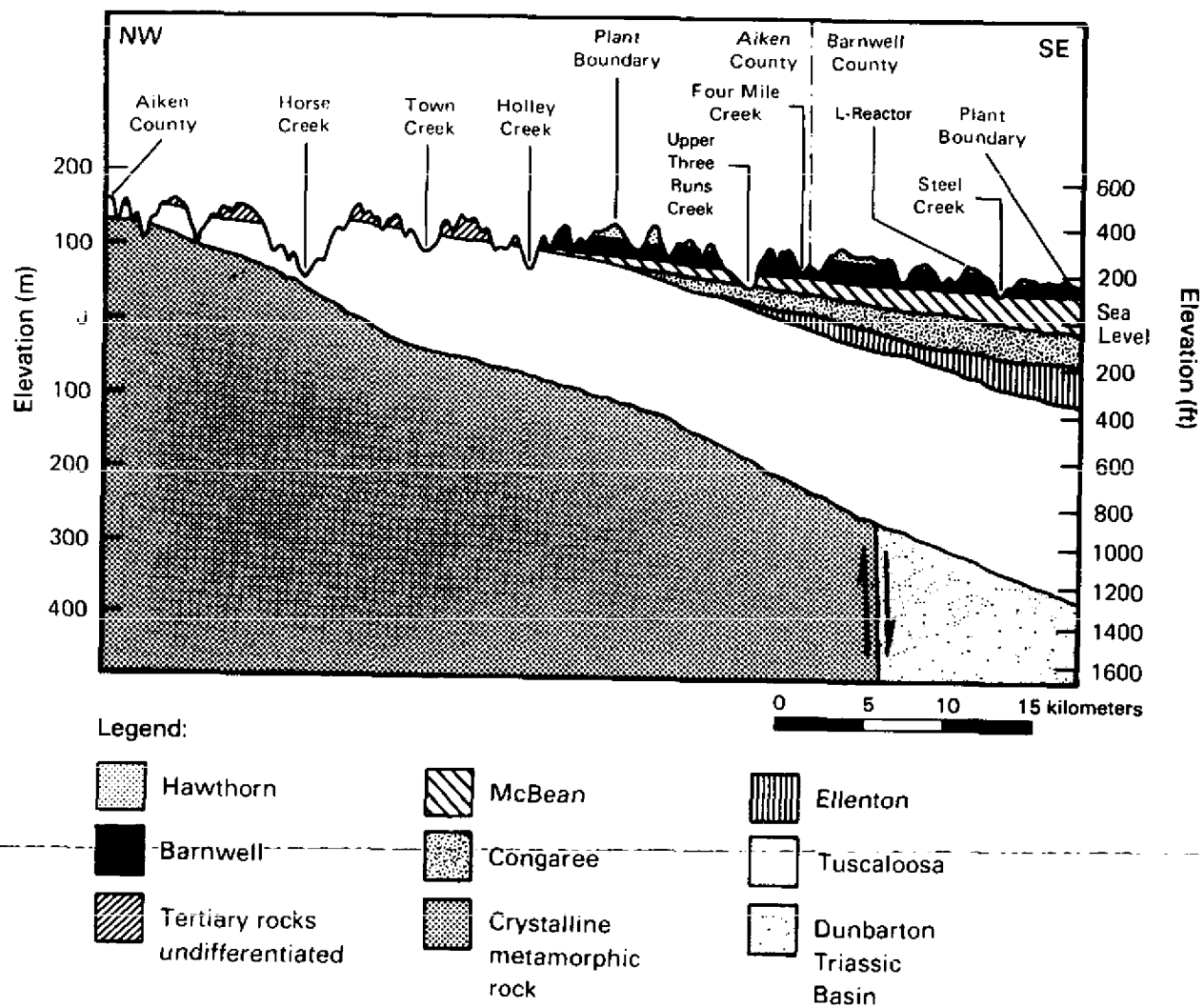
3.3 GEOLOGY AND SEISMOLOGY

3.3.1 Geology

3.3.1.1 Geologic setting

The SRP is located in the Aiken Plateau physiographic division of the Upper Atlantic Coastal Plain of South Carolina (Cooke, 1936; Du Pont, 1980a). Figure 3-5 shows that the topography in the vicinity of the L-Reactor site at Savannah River Plant is characterized by interfluvial areas with narrow, steep-sided valleys. The relief in the region of the L-Reactor site measures about 20 meters.

The L-Reactor site is about 40 kilometers southeast of the fall line (Davis, 1902) that separates the Atlantic Coastal Plain physiographic province from the Piedmont physiographic province of the Appalachian region (Appendix F, Figure F-1). Crystalline rocks of Precambrian and Paleozoic age underlie the gently seaward-dipping Coastal Plain sediments of Cretaceous and younger age. Sediment-filled basins of Triassic and Jurassic age (exact age is uncertain) occur within the crystalline basement throughout the coastal plain of Georgia and the Carolinas (Du Pont, 1980a). One of these, the Dunbarton Triassic Basin, underlies parts of Savannah River Plant.



Source: Siple (1967).

Figure 3-5. Generalized northwest to southeast geologic profile across the Savannah River Plant.

3.3.1.2 Stratigraphy

Coastal Plain sediments in South Carolina range in age from Cretaceous to Quaternary; they form a seaward-dipping and thickening wedge of interstratified beds of mostly unconsolidated sediments. At the L-Reactor site, these sediments are approximately 400 meters thick (Siple, 1967). The base of the sedimentary wedge rests on a Precambrian and Paleozoic crystalline basement, which is similar to the metamorphic and igneous rocks of the Piedmont, and on the siltstone and claystone conglomerates of the down-faulted Dunbarton Triassic Basin. Immediately overlying the basement is the Tuscaloosa Formation of Upper Cretaceous age, which is about 230 meters thick and composed of prolific water-bearing sands and gravels separated by prominent clay units. Overlying the Tuscaloosa is the Ellenton Formation, which is about 18 meters thick and consists of sands and clays interbedded with coarse sands and gravel. Four of the formations shown in Figure 3-5--the Congaree, McBean, Barnwell, and Hawthorn--comprise the Tertiary (Eocene and Miocene) sedimentary section, which is about 85 meters thick and consists predominantly of clays, sands, clayey sands, and sandy marls. The near-surface sands of the Barnwell and Hawthorn Formations are usually in a loose to medium-dense state; they often contain thin sediment-filled fissures (clastic dikes) (Du Pont, 1980a).

Quaternary alluvium has been mapped at the surface in floodplain areas. Soil horizons at the site are generally uniform and relatively shallow, about 1 meter deep. They are characterized by bleached Barnwell-Hawthorn sediments, which result in a light tan sandy loam.

Section 3.4.2 and Appendix F present additional stratigraphic information.

3.3.2 Seismology

3.3.2.1 Geologic structures

The Dunbarton Triassic Basin, which is similar to grabens in the Basin and Range Province in Nevada, underlies the Savannah River Plant at the L-Reactor site (Siple, 1967). Other Triassic-Jurassic basins have been identified in the Coastal Plain tectonic province within 300 kilometers of the site (Du Pont, 1980a; Popenoe and Zietz, 1977). The Piedmont, Blue Ridge, and Valley and Ridge tectonic provinces, which are associated with Appalachian mountain building, are northwest of the Fall Line. Several fault systems occur in and adjacent to the Piedmont and the Valley and Ridge tectonic provinces of the Appalachian system; the closest of these is the Belair Fault Zone, about 40 kilometers from the site. The U.S. Nuclear Regulatory Commission has determined that the Belair Fault is not capable within the meaning of 10 CFR 100 (Case, 1977). Studies sponsored by Georgia Power Company have shown that the faults postulated to occur near the southeastern boundary of the Savannah River Plant and about 40 kilometers southeast (Faye and Prowell, 1982) are not capable and that they might not exist (Georgia Power Company, 1982). There is no evidence of any recent displacement along any faults within 300 kilometers of the L-Reactor site (Du Pont, 1980a). In addition, no apparent association exists between local seismicity and specific faults near the Savannah River Plant, with the possible exception of the geophysically inferred faults (Lyttle et al., 1979; Behrendt et al., 1981; Talwani, 1982) in the meizoseismal area of the 1886 Charleston

earthquake, which occurred approximately 145 kilometers from the Plant (Du Pont, 1982b).

Surface mapping and subsurface investigations in the L-Reactor region did not detect any faulting of the sedimentary strata or any other geologic hazards that would pose a threat to the reactor. Several surficial faults, generally less than 300 meters in length and with displacements of less than 1 meter, were mapped within several kilometers of the L-Reactor site. None of these faults is considered capable (Du Pont, 1980a).

3.3.2.2 Seismicity

Two major earthquakes have occurred within 300 kilometers of the L-Reactor site: the Charleston earthquake of 1886, which had an epicentral Modified Mercalli Intensity (MMI) of X, was located about 145 kilometers away; and the Union County, South Carolina, earthquake of 1913, which had an epicentral shaking of MMI VII to VIII, was located approximately 160 kilometers away (Langley and Marter, 1973). An estimated peak horizontal shaking of 7 percent of gravity (0.07g) was calculated for the site during the 1886 Charleston earthquake (DOE, 1982a). No reservoir-induced seismicity is associated with Par Pond (see Figure 3-2) (Du Pont, 1982b).

Probabilistic and deterministic analyses commensurate with the criteria used by NRC (10 CFR 100) have established a design-basis earthquake acceleration of 0.20g for key seismic-resistant buildings at Savannah River Plant. This acceleration is predicted to be exceeded only once in about 5000 years (Du Pont, 1982b). (See Section 4.2.2.3.)

3.4 HYDROLOGY

3.4.1 Surface-water hydrology

3.4.1.1 Savannah River

The Savannah River Plant (SRP) is drained almost entirely by the Savannah River, one of the major drainage networks in the southeastern United States (Langley and Marter, 1973). The peak historic flood between 1796 and 1983--10,190 cubic meters per second--corresponds to a stage of about 36 meters (DOE, 1982a), which is about 40 meters below the elevation of L-Reactor. A domino-type failure of dams on the Savannah River above Savannah River Plant would produce a flow of 42,500 cubic meters per second with a corresponding stage of 43.6 meters at Savannah River Plant (Du Pont, 1980a), which is well below the elevation of L-Reactor. The two nearest upstream reservoirs, Clarks Hill (completed in March 1953, with 3.1×10^9 cubic meters of storage) and Hartwell (completed in June 1961, with 3.1×10^9 cubic meters of storage), provide power, flood control, and recreational areas. These reservoirs and the New Savannah River Bluff Lock and Dam at Augusta, Georgia, have stabilized the river flow at Augusta to a yearly average of 288.8 cubic meters per second (Bloxham, 1979) and 295 cubic meters per second at Savannah River Plant. Russell Reservoir, which

began filling in December 1983, will furnish 1.2×10^9 cubic meters of storage to further stabilize Savannah River flows. |TC

Since 1963, it has been the operating practice of the U.S. Army Corps of Engineers to attempt to maintain a minimum flow of 178.4 cubic meters per second below the New Savannah River Bluff Lock and Dam at Butler Creek (River Mile 187.4, near Augusta, Georgia) (COE, 1981). During the 18-year period from 1964 to 1981 (climatic years ending March 31), the average of the lowest 7-consecutive-day flow each year measured at the New Savannah River Bluff Lock and Dam was 181 cubic meters per second (Watts, 1982) or about 2.3 cubic meters per second less than at Savannah River Plant (Ellenton Landing, River Mile 156.8).

An extreme value analysis was used to assess low-flow conditions on the Savannah River. Due to the change in the operating practice of the Corps of Engineers in 1963, the annual lowest 7-day flow data for years prior to 1963 were not considered; a 20-year period of record, climatic years 1964 to 1983 (through March), was used in the analysis. Table 3-3 presents the results of this analysis.

Table 3-3. Seven-day low-flow conditions on the Savannah River at Savannah River Plant^a

Recurrence interval (yrs)	Flow at Ellenton Landing (m ³ /sec)
2	182.8
5	168.5
10	159.0
20	149.9
30	144.6
50	138.0

^aBased on an external distribution that provided the best fit value (0.9909) of the eight extreme value models suggested by Petruaskas and Aagaard (1970).

Figure 3-6 shows the mean monthly flow rates for the Savannah River measured at Augusta, Georgia from January 1964 through September 1981. Highest flows occur in the winter and spring, and the lowest occur in the summer and fall. Also indicated in this figure are long-term mean and 7-day, 10-year low flows at Ellenton Landing. River flow at Ellenton Landing is usually 9 to 13 cubic meters per second greater than at Augusta, Georgia.

Table 3-4 compares the total river flows at Ellenton Landing for 1979 to 1982. The effects of the 1981 drought are clearly seen. Based on the low-flow analysis (Table 3-3), the drought produced 1-in-50-year 7-day low flows at Savannah River Plant.

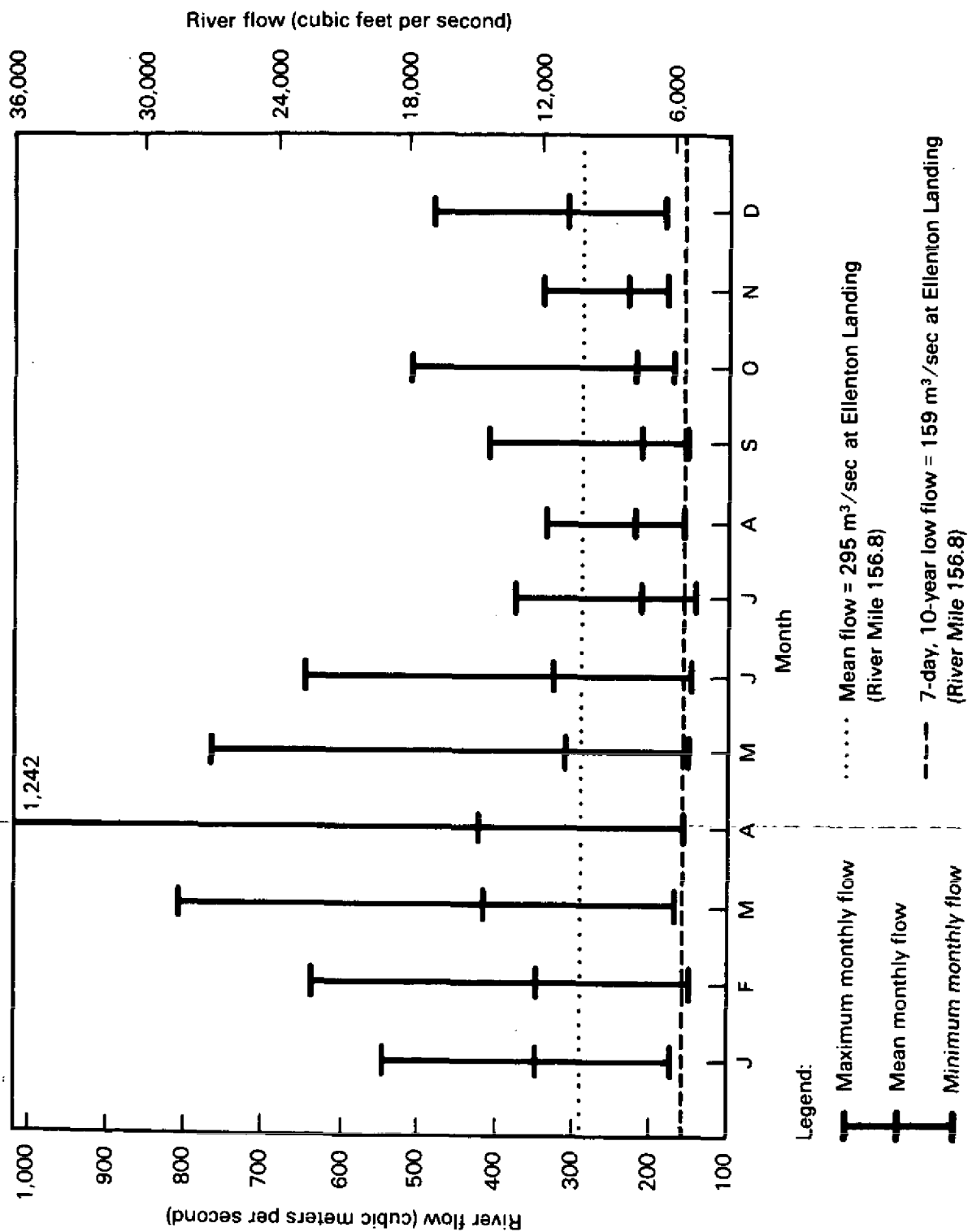


Figure 3-6. Mean monthly flow rates of the Savannah River from 1964-1981 at River mile 187.5 (data derived from USGS gaging station, near Augusta, Georgia).

Table 3-4. Summary of Savannah River flow and temperature measurements 3 kilometers above and 16 kilometers below Savannah River Plant, 1979-1982^a

Parameter	1979		1980		1981		1982	
	Above	Below	Above	Below	Above	Below	Above	Below
Total flow volume (10 ¹³ liters per year)	1.0	1.3 ^b	1.1	1.3	0.44 ^c	0.53 ^c	0.65	0.78
Temperature (°C)								
Mean	17.2	17.5	18.0	18.0	19.0	20.0	17.0	18.0
±2 Std. Dev.	11.7	11.9	11.1	11.3	9.5	10.0	10.0	11.0
Maximum	24.5	24.5	25.0	26.0	25.0	26.0	24.0	25.0
Minimum	8.5	8.5	1.5	8.0	12.0	12.0	6.8	6.5

^aAdapted from Du Pont (1980b, 1981a, 1982c, 1983a).

^bEstimated from Ellenton Landing flow data.

^cIncludes third quarter 1981 data when the Corps of Engineers reduced flows to conduct minimum flow testing at SRP pumphouses.

Duke Power Company has entered into an agreement with the City of Greenville, South Carolina, to provide an interbasin transfer of as much as 0.53 cubic meter per second in 1985 and 8.3 cubic meters per second by 2020 from Lake Keowee. The States of Georgia and South Carolina have asked the Corps of Engineers for permission to withdraw as much as 1.8 cubic meters per second (total) from Lake Hartwell.

EL-1

The Corps of Engineers maintains, in accordance with its agreement with Duke Power Company, that the interbasin transfer from Lake Keowee to the City of Greenville is legal provided it has no effect on the ability of the Corps to generate electric power at Lake Hartwell and Clarks Hill. The Corps of Engineers is presently assessing the requests by South Carolina and Georgia to withdraw water from Lake Hartwell. This assessment will include the ability of the Corps to maintain its navigation project below the New Savannah Bluff Lock and Dam and to meet its electric-power-generation requirements. It will also consider the effects of the interbasin transfer. Until the Corps of Engineers completes its assessment, it will maintain the flow below the New Savannah Bluff Lock and Dam at the current levels.

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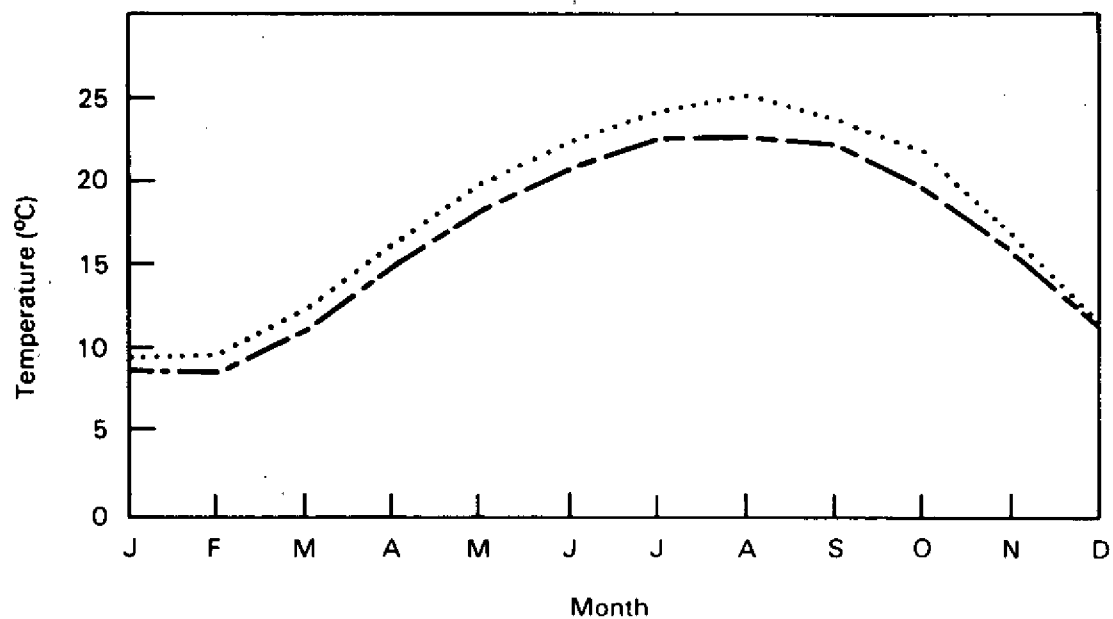
The 1979-1982 average temperature of the Savannah River 3 kilometers above Savannah River Plant was 17.8°C with a range of 1.5 to 26.0°C (see Table 3-4). Similarly, below Savannah River Plant the average temperature was 18.4°C and the range was 6.5 to 26.0°C. Monthly average daily-maximum temperatures above and below Savannah River Plant for the period 1960-1970 are presented in Figure 3-7. The river temperature increased by 1.1°C on the average over the 40 river miles between Ellenton Landing and the U.S. Highway 301 bridge. This was due, in part, to the natural warming as the water tended toward its equilibrium temperature; discharges from Clarks Hill Lake were typically about 5°C cooler than the water temperatures prior to dam construction (Neill and Babcock, 1971).

As shown in Figure 3-7, June, July, August, and September are the warmest river temperature months; monthly average temperatures and standard deviations are listed in Table 3-5. The average river temperature during these months was about 25 percent higher than the annual average river temperature. From June 1955 through September 1982, the river temperature at Ellenton Landing equalled or exceeded 28°C-three-times-and-equalled-or-exceeded 28.3°C-once.

TC|

Table 3-5. Mean maximum daily temperature, 1960-1969 (°C)

Month	Ellenton Landing		Highway 301 bridge	
	Monthly average	Standard deviation	Monthly average	Standard deviation
June	21.0	1.5	22.9	2.2
July	22.7	0.7	24.8	1.3
August	23.1	0.7	25.1	1.0
September	22.3	0.9	23.9	1.0



Legend:

..... Savannah River at Millhaven (U.S. Hwy. 301 bridge), River Mile 118.7
 - - - - - Savannah River at SRP (Ellenton Landing) River Mile 156.8

Source: DOE (1982a).

Figure 3-7. Savannah River monthly average daily-maximum temperatures for 1960-1970.

During the February, March, April, and May fish spawning season the monthly average daily-maximum temperatures and standard deviations at Ellenton Landing for the same period of record were 8.7°C and 1.0°C, 11.0°C and 1.3°C, 15.4°C and 1.3°C, and 18.8°C and 1.6°C, respectively.

3.4.1.2 SRP streams and swamp

The SRP site is drained almost entirely by five principal systems (drainage areas are in parentheses): (1) Upper Three Runs Creek (490 square kilometers); (2) Four Mile Creek (including Beaver Dam Creek) (90 square kilometers); (3) Pen Branch (90 square kilometers); (4) Steel Creek (90 square kilometers); and (5) Lower Three Runs Creek (470 square kilometers). These streams rise on the Aiken Plateau and descend 30 to 60 meters before discharging to the Savannah River. The sandy soils of the area permit rapid infiltration of rainfall; seepage from these soils furnishes the streams with a rather constant supply of water throughout most of the year (Langley and Marter, 1973).

Upper Three Runs Creek is the only major onsite stream that has never received thermal discharges (Du Pont, 1982a). One of the principal tributaries of Upper Three Runs Creek, Tims Branch, received process and nonprocess liquid effluents (from the 700-A and 300-M Areas of Savannah River Plant) of about 0.05 cubic meter per second until May 1982. After this time, discharges of wastewater effluents from M-Area (0.016 cubic meter per second) were diverted to the M-Area basin.

Lower Three Runs Creek has the second largest watershed of the SRP streams. In 1958, its headwaters were impounded to form Par Pond for the recirculation of cooling water from P- and R-Reactors. Cooling water from P-Reactor was discharged to Steel Creek until 1963, when it was diverted to Par Pond. Four Mile Creek receives nonthermal discharges from F- and H-Separations Areas and thermal discharges from C-Reactor. Pen Branch receives thermal discharges from K-Reactor. Reactor secondary cooling-water effluent is discharged at a rate of 11 cubic meters per second.

The L-Reactor site is drained by both Steel Creek and Pen Branch. Steel Creek has been used in the past to receive the reactor coolant discharge. The headwaters of Steel Creek rise near P-Area and flow southwesterly for about 7 kilometers, turn south for about 9 kilometers, and enter the Savannah River swamp about 3 to 5 kilometers from the river. A delta of about 100 acres surrounded by a partial tree-kill zone of another 180 acres has developed where the creek enters the swamp (Du Pont, 1983b). Beyond the delta, Steel Creek is joined by the flow from Pen Branch and some flow from Four Mile Creek before it discharges into the Savannah River near Steel Creek Landing (see Figure 3-2).

During the 1983 water year (October 1982 through September 1983), the flow of Steel Creek at Road B ranged between 0.28 and 3.96 cubic meters per second. The average flow for this period was 0.62 cubic meter per second. Of this average flow, about 0.45 cubic meter per second was discharged from P-Reactor at near-ambient temperatures (McAllister, 1983). Farther downstream at Cypress Bridge, about 2.8 kilometers below Road A, the average flow of Steel Creek for calendar years 1978 through 1980 was 1.36 cubic meters per second. After subtracting the P-Reactor contribution, the natural flow of Steel Creek at Cypress

Bridge is calculated to be about 0.91 cubic meter per second. Du Pont (1982a) estimated the natural flow of Steel Creek to be 1.0 cubic meter per second, based on drainage area considerations. Maximum daily flow rates (both natural and with discharges from P-Reactor) were measured between 4.2 and 8.2 cubic meters per second during the past 8 years.

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As listed in Table 3-6, Steel Creek has had a varied history with respect to the release of reactor effluents. The release of thermal effluents into Steel Creek from L- and P-Reactors reached a peak of about 23 cubic meters per second in 1961. In 1963, P-Reactor effluents were diverted to Par Pond, and thermal discharges to the creek were reduced to about 11 cubic meters per second, about 1.3 times the maximum flow expected at Cypress Bridge after heavy rains. Since 1968, Steel Creek has received only infrequent and short-term inputs of thermal effluents (Smith, Sharitz, and Gladden, 1981, 1982a; Du Pont, 1982a).

Table 3-6. Reactor-Area discharges to Steel Creek^a

Years	Discharge (m ³ /sec)		
	P-Reactor	L-Reactor	Total
1954 to 1958	5.6	5.7	11.3
1958 to early 1961	9.3	9.3	18.6
Mid-1961	11.3	11.3	22.6
Late 1961 to late 1963	9.3	11.3	20.6
November 1963 to February 1968	0.4 ^b	11.3	11.7
February 1968 to 1980	0.4 ^b	0.0	0.4 ^b
1981 to present	0.5 ^b	0.002 ^c	0.5 ^{b,c}

^aAdapted from Du Pont (1982a).

^bFlow from P-Area sources at about ambient temperature.

^cFlow from sanitary and domestic sources from L-Area at ambient temperature. During cold-water testing, the flow has approached 6.2 cubic meters per second.

Table 3-7 compares stream characteristics before and after Steel Creek received heated discharges from L- and P-Reactors. Between 1951 and 1972, the Steel Creek channel width increased more than three times due to effluent scour.

The three streams that have received the greatest input of thermal effluent (Four Mile Creek, Pen Branch, and Steel Creek) flow into a contiguous swamp of about 10,240 acres (Du Pont, 1983b) that is separated from the main flow of the Savannah River by a 3-meter-high natural levee along the river bank. These streams generally flow as shallow sheets, with well-defined channels only where they enter the swamp and near breaches in the levee (Smith, Sharitz, and Gladden, 1981). The combined natural flow and reactor effluent discharges have a strong influence on water levels in the swamp during nonflood conditions.

The flow of water in the swamp is altered when the Savannah River is in flood stage (about 27.7 meters) with a flow rate of about 440 cubic meters per second. Under flooding conditions, Four Mile Creek, Pen Branch, and Steel Creek

Table 3-7. Steel Creek stream characteristics^a

Date	Width (m)	Average depth (m)	Flow rate (m ³ /sec)	Temperature (°C)
May 1951	5.1	0.30	0.59 ^b	16.1
June 1972	16.5	0.37	0.79	24.6

^aBased on measurements taken at Road A and adapted from Du Pont (1982a).

^bJuly 1951 determination.

discharge to the Savannah River at Little Hell Landing after crossing an offsite swamp (Creek Plantation Swamp). An analysis of the data from 1958 through 1980 indicates that on the average the Savannah River reaches flood stage at the Savannah River Plant 79 days, or 22 percent of each year, predominantly from January through April (see Figure 3-6). This result is in agreement with the results of a similar analysis performed by Langley and Marter (1973).

3.4.1.3 Surface-water use

The Savannah River downstream from Augusta, Georgia, is classified by the State of South Carolina as a Class B waterway, suitable for agricultural and industrial use, the propagation of fish, and--after treatment--domestic use. The river upstream from the Savannah River Plant supplies municipal water for Augusta, Georgia, and North Augusta, South Carolina. Downstream, the Beaufort-Jasper Water Authority in South Carolina (River Mile 39.2) withdraws about 19,700 cubic meters per day (0.23 cubic meter per second) to supply domestic water for a population of about 51,000. The Cherokee Hill Water Treatment Plant at Port Wentworth, Georgia (River Mile 29.0), withdraws about 116,600 cubic meters per day (1.35 cubic meters per second) to supply a business-industrial complex near Savannah, Georgia, that has an estimated consumer population of about 20,000 (Du Pont, 1982a). Plant expansions for both systems are planned for the future.

The Savannah River Plant currently withdraws a maximum of 26 cubic meters per second (about 63 percent of the maximum pumping rate of 41 cubic meters per second) from the river, primarily for use as cooling water in production reactors and coal-fired power plants (Du Pont, 1982a). Almost all of this water returns to the river via SRP streams (Du Pont, 1981b). The river receives sewage treatment effluents from Augusta, Georgia, and North Augusta, Aiken, and Horse Creek Valley, South Carolina, and other waste discharges along with the heated cooling water from Savannah River Plant via its tributaries. The cooling-water withdrawal and discharge rate of about 1.2 cubic meters per second for both units of the Alvin Vogtle Nuclear Plant is expected later in the 1980s (Georgia Power Company, 1974). The Urquhart Steam Generating Station at Beech Island withdraws approximately 7.4 cubic meters per second of once-through cooling water. Upstream, recreational use of impoundments on the Savannah River, including water contact recreation, is more extensive than it is near Savannah

River Plant and downstream. No uses of the Savannah River for irrigation have been identified in either South Carolina or Georgia (Du Pont, 1982a).

The water quality of the Savannah River is discussed in Chapter 4. Historic data demonstrate that the water quality of the river downstream of Savannah River Plant is similar to the water quality upstream.

3.4.2 Subsurface hydrology

3.4.2.1 Hydrostratigraphic units

Three distinct hydrogeologic systems underlie Savannah River Plant: (1) the Coastal Plain sediments, where water occurs in porous sands and clays; (2) the buried crystalline metamorphic rock beneath the sediments, where water occurs in small fractures in schist, gneiss, and quartzite; and (3) the Dunbarton Basin (Triassic age) within the crystalline metamorphic complex, where water occurs in intergranular spaces in mudstones and sandstones. The latter two systems are unimportant as ground-water sources near SRP.

The Coastal Plain sediments, which contain several prolific and important aquifers, consist of a wedge of stratified sediments that thickens to the south-east. Near L-Reactor, the sediments are about 400 meters thick and consist of sandy clays and clayey sands. The sandier beds form aquifers and the clayier beds form confining beds. The Coastal Plain sediments across the SRP generally consist of the Barnwell (combined with the Hawthorn as one mapping unit), McBean, Congaree, Ellenton, and Tuscaloosa Formations (Figure 3-5). Among these, the Tuscaloosa Formation is a particularly prolific ground-water unit because of both its thickness, approximately 180 meters beneath H-Area, and its high permeability. Surficial deposits, including terrace sediments and alluvium, are not important sources of ground water at SRP. The lithology and water-bearing characteristics of the hydrostratigraphic units underlying Savannah River Plant are described in Table 3-8. Additional detail is provided in Table F-1 and the text of Appendix F.

Ground water beneath the central portions of the SRP, including the L-Area, generally occurs under confined (artesian) conditions; in wells, the ground water rises to a potentiometric (piezometric) level above the water level encountered in the formation. However, ground water in the Barnwell Formation and overlying units generally occurs under unconfined (water table) conditions; in wells, this ground water remains at the level encountered in the formation. The elevation of the free-standing ground water above a sea-level datum is referred to as the "head."

In the central part of the Savannah River Plant [including the Separations (F- and H-) Areas and the L-Area], the Barnwell and McBean Formations and the McBean and Congaree Formations (Figure 3-8) are separated by layers informally called the "tan clay" and the "green clay," respectively, in SRP studies. The lowest unit of the Barnwell Formation is the tan clay. Borings in the Separations Areas and about 2 kilometers east of the Central Shops (Figure 3-2) indicate that the tan clay is about 2 meters thick, and that it commonly consists of two thin clay layers separated by a sandy zone (D'Appolonia, 1980; Du Pont,

EL-11

Table 3-8. Hydrostratigraphic units in the vicinity of SRPa

Geologic unit	Geologic age	Outcrop	Description	Water yield	Thickness (m)
Alluvium ^b	Recent epoch	River and creek bottoms	Fine to coarse sand, silt, and clay	Very little	0 to 9.5
Terrace deposits ^b	Pleistocene epoch	In flood plains and terraces of stream valleys	Tan to gray sand, clay, silt, and gravel on higher terraces	Moderate to none	0 to 9.5
Alluvium ^b	Pliocene epoch	Surface of Aiken Plateau	Gravel and sandy clay	Little or none	0 to 6
Hawthorn ^b	Miocene epoch	Large part of ground surface	Tan, red, and purple sandy clay with numerous clastic dikes	Little or none	0 to 25
Barnwell ^b	Eocene epoch	Large part of ground surface near streams	Red, brown, yellow, and buff, fine to coarse sand and sandy clay	Limited but sufficient for domestic use	0 to 30
McBean and Congaree ^b	Eocene epoch	In banks of larger streams	Yellow-brown to green, fine to coarse, glauconite quartz sand, intercalated with green, red, yellow, and tan clay, sandy marl, and lenses of siliceous limestone	Moderate to large	30 to 75
Ellenton ^b	Upper Cretaceous epoch	None on SRP	Dark gray to black sandy lignitic micaceous clay containing disseminate crystalline gypsum and coarse quartz sand	Moderate to large; higher sulfate and iron than water from other formations	1 to 30
Tuscaloosa ^b	Upper Cretaceous epoch	None on SRP	Tan, buff, red, and white; crossbedded, micaceous quartzitic and arkosic sand and gravel imbedded with red, brown, and purple clay and white kaolin	Large, well production up to 7.6 m ³ /min; soft; low in total solids	170 to 250

Table 3-8. Hydrostratigraphic units in the vicinity of SRP^a (continued)

Geologic unit	Geologic age	Outcrop	Description	Water yield	Thickness (m)
Newark Series "Red Beds" ^c	Triassic period	None on SRP	Dark-brown and brick-red sandstone, siltstone, and claystone containing gray calcareous patches. Funglomerates near border.	Very little	>900
Basement rocks of the Slate Belt and Charlotte group ^d	Precambrian and Paleozoic eras	None on SRP	Hornblende gneiss, chlorite-hornblende schist, lesser amounts of quartzite. Covered by saprolite layer derived from basement rock.	Very little	Many thousands

^aAdapted from Siple (1967); see Table F-1 for a more detailed summary of properties of the hydrostratigraphic units.

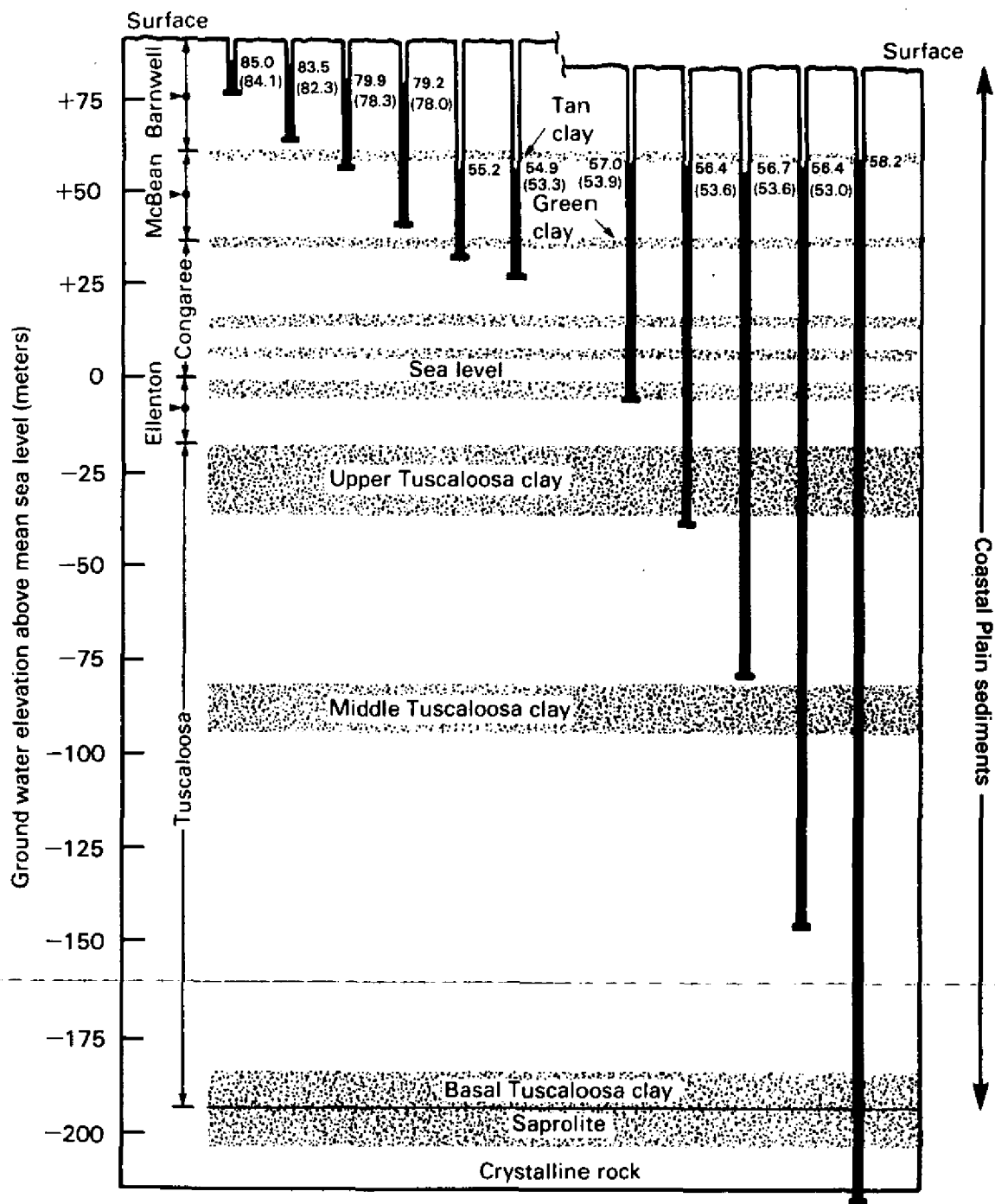
^bCoastal-plain sediments.

^cDunbarton Basin sediments.

^dCrystalline and metamorphic rock.

| TC

TE



Legend:



Water elevations (heads) in meters. Values are those existing in 1972 with 1982 measurements given in parentheses.

Sources: ERDA (1977), Du Pont (1983c).

Figure 3-8. Hydrostatic head of ground-water near H-Area in relation to principal hydrostratigraphic units.

TC

1983c). In the L-Area, the tan clay is not readily evident from foundation borings, drillers, logs, or geophysical logs; however, even in other SRP areas where it supports a significant head difference, this clay is not always apparent in soil cores.

The green clay, deposited under marine conditions and therefore expected to be continuous over large areas, is hydrogeologically significant because it supports a large head difference between ground water in the McBean and ground water in the Congaree Formations; this head difference is as much as 21 meters near the Central Shops and 24 meters in the Separations Areas, even though the clay is only 2 to 3 meters thick (D'Appolonia, 1980; Du Pont, 1983c). The green clay is effective in preventing the downward migration of contaminants (based on tritium measurements) from the McBean into the Congaree in H-Area (Marine, 1965). This observation is supported by recent analyses of ground water from well 35-D (see the boring location on Figure F-34). During investigations on the capability of the postulated Millett fault, the green clay near P-Area was correlated with the Blue Bluff Member of the Lisbon Formation in Georgia (Georgia Power Company, 1982); in the southeastern part of SRP down dip from the Separations Areas, the green clay is believed to be about 18 meters thick (Du Pont, 1983c). Based on geophysical logs of water wells in the L-Area (see Figure F-24), the green clay is about 7 meters thick. At the Par Pond pumphouse, along the strike from L-Reactor, the green clay also supports a large head difference; it also appears to have effectively protected the Congaree ground water from the large (27,000 picocuries per liter) concentrations of tritium in Par Pond (Ashley and Zeigler, 1979). In the central part of SRP, this clay directs much of the water in the McBean laterally to local creeks.

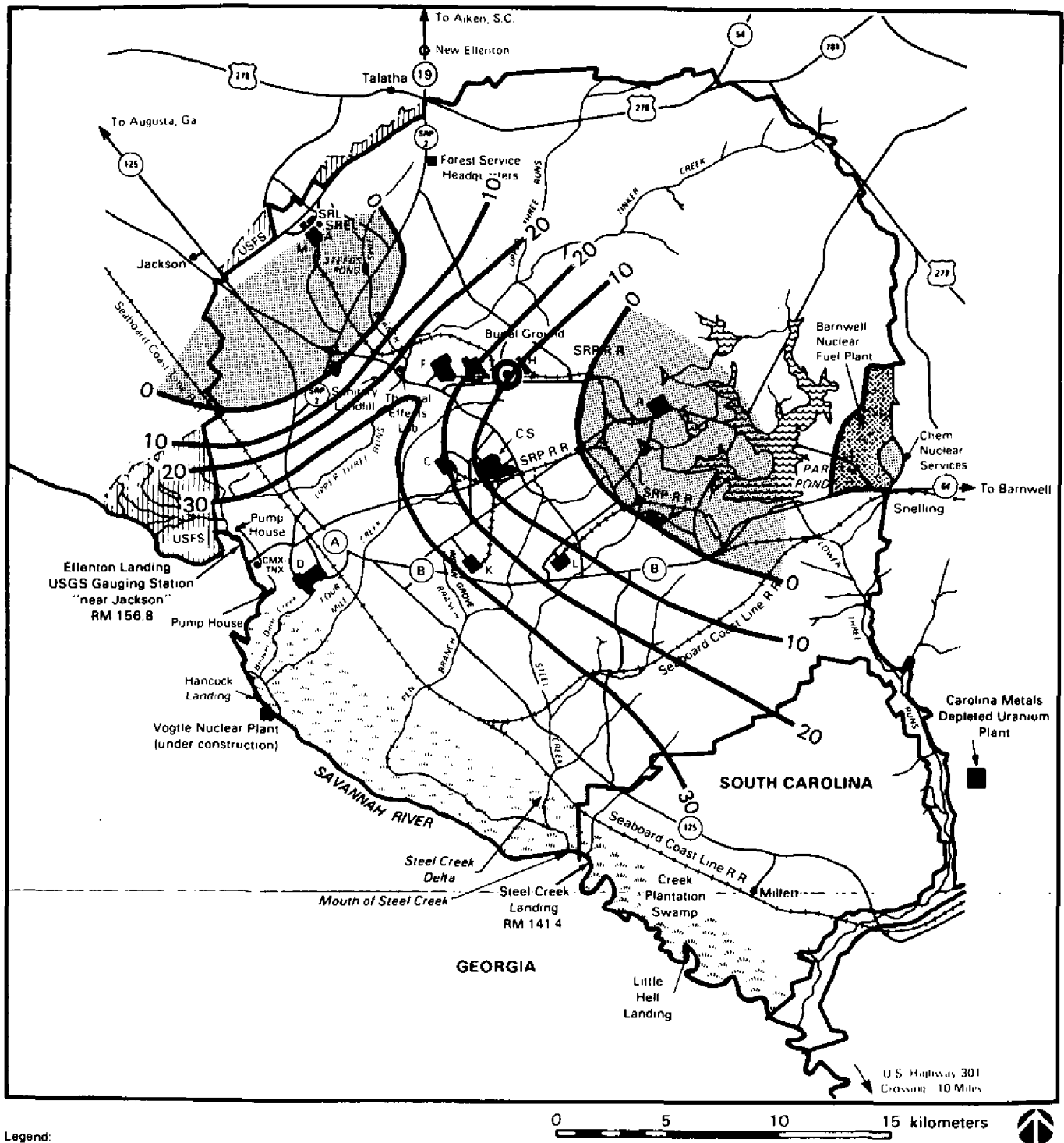
EL-11

Up dip from the Separations Areas, the tan clay seems to be absent from the stratigraphic section and the green clay is discontinuous. However, in A-Area the green clay might be sufficiently continuous to affect ground-water flow patterns. The ground-water flow direction is to the west-southwest in the water table. Lower in the Tertiary section, the predominant flow is to the south.

Throughout the SRP, the clay at the base of the Congaree and the upper clay layer of the Ellenton Formation provide an effective confining unit for the sands of the Ellenton-upper Tuscaloosa aquifer (see Table F-1).

As shown on Figure 3-8, the heads in the Ellenton and Tuscaloosa Formations are higher than those in the Congaree (upward head differentials) in the central portion of SRP, thus preventing downward movement of water from the Congaree to the Ellenton. This condition is caused by the drawing down of the head in the Congaree by natural drainage into Upper Three Runs Creek and the Savannah River. An approximation of the area where the head difference is upward from the Tuscaloosa to the Congaree is shown in Figure 3-9. F-, H-, and L-Areas are within this area, but M-Area is not.

The head relationships in the Coastal Plain sediments in the northwest part of Savannah River Plant (M-Area) are quite different from those near the L-Reactor. In this updip area, the green clay is discontinuous and is thinner than it is farther down dip, and the tan clay (Figure 3-8) has disappeared entirely. Thus, there is less impedance to downward vertical flow within the Tertiary sediments. Another important factor is that the hydrologic conductivity of the Congaree Formation in M-Area is less than that in the central part of Savannah River Plant because the sediments near M-Area are not as well



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caloosa
jaree

Legend:

C, K, R, L, P Reactor Areas (C, P, K are operating) Road A = Highway 125
F, H Separations Areas
M Fuel and Target Fabrication
D Heavy Water Production
A Savannah River Laboratory and
Administration Area
U Temporary construction area
RM River Mile

F, H Separations Areas

M Fuel and Target Fabrication

D Heavy Water Production

A Savannah River Laboratory and Administration Area

U Temporary construction area

RM River Mile

Area where the Congaree head exceeds the Tuscaloosa head.
Contour showing locations where the head in the Tuscaloosa is 10 feet
(1.0 foot = 0.3048 meter) above the head in the Congaree.
Developed from Figures F-9 and F-10.

Developed from Figures F-9 and F-10.

Figure 3-9. Head difference between upper Tuscaloosa and Congaree Formations at SRP (May 11, 1982).

sorted. As a result of these hydrogeologic characteristics, water elevations decrease with increasing depth from the Congaree to the Tuscaloosa in M-Area (i.e., a downward head differential exists between the Congaree and Tuscaloosa Formations). Closer to the Savannah River, the natural discharge from the Congaree draws its head down below that of the Tuscaloosa. This is an important factor in reducing the likelihood that any surface contamination will enter the important, prolific Tuscaloosa aquifer from the Congaree.

The locations of areas where there is a head reversal between the Congaree and the Tuscaloosa Formations (i.e., the latter's head being higher than the former's) are shown in Figure 3-9; these relationships are general and are not valid in the vicinity of production wells. This head difference map shows that the head in the Tuscaloosa is higher than the head in the Congaree in a broad area within about 10 kilometers of the Savannah River and Upper Three Runs Creek. The head in the Congaree is higher than that of the Tuscaloosa in an area surrounding A- and M-Areas and in the vicinity of Par Pond.

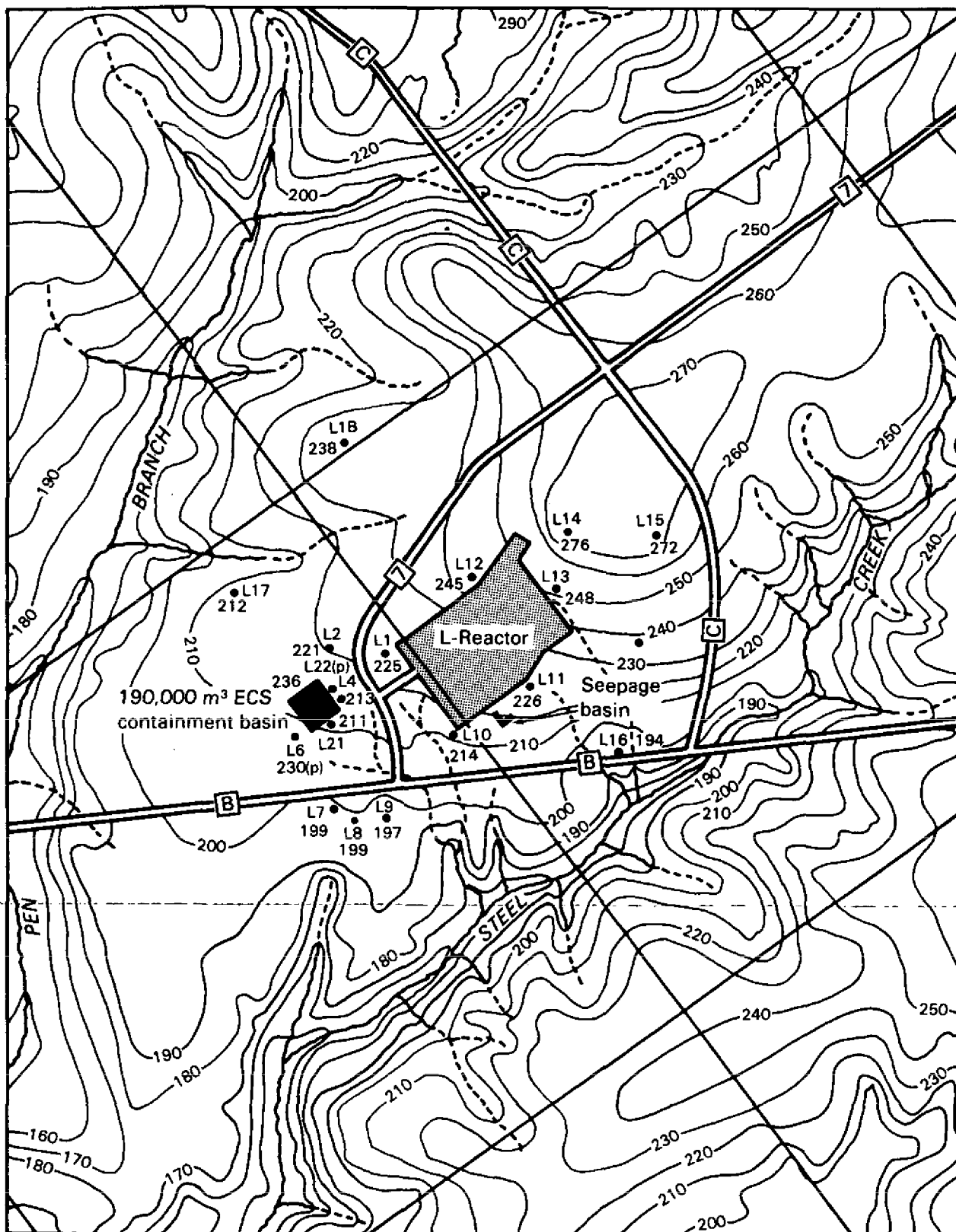
In the L-Reactor area, the water table is generally 3 to 6 meters below the ground surface (Appendix F, Figure F-24). Shallow ground water beneath the L-Reactor area generally moves to the south-southeast in the direction of Steel Creek and to the west-southwest in the direction of Pen Branch (Figure 3-10).

A more detailed discussion of the hydrostratigraphic units and their head relationships across the entire site and in specific areas is given in Appendix F and in Du Pont (1983c).

3.4.2.2 Ground-water movement

Water moves through the ground from areas of high potential energy (usually measured by the combined elevation and pressure heads) to areas of lower energy. In general, on the Atlantic Coastal Plain, the gradient is seaward from the higher areas of the Aiken Plateau toward the continental shelf. Of major significance is the modification of this general southeastward movement caused by the incision of the Savannah and Congaree Rivers and, on a local basis, the incision of the smaller tributaries to these rivers. Ground water in the regions of these rivers and tributaries is diverted toward the hydraulic-energy low caused by natural discharge to the surface water. The depth of dissection at Savannah River Plant by the southwestward-flowing site streams has a significant influence in the direction of flow in most hydrostratigraphic units. The direction of flow in the shallow ground water is most affected by small streams; the direction of flow in the deeper ground water is most affected by major tributaries. The direction of flow in the Ellenton and Tuscaloosa Formations is affected only by the Savannah River itself. Locally, the normal direction of ground-water flow in any unit is modified by ground-water withdrawals from wells.

The energy levels (heads) of the Tuscaloosa Formation, the primary aquifer in the region, and the location of its outcrop areas, are shown in Figures 3-5 and F-1 (Appendix F). Where the outcrop area is high in elevation, as on the Aiken Plateau in the northeast sector of SRP (Figure F-1), water naturally recharged to the Tuscaloosa Formation exceeds the water naturally discharged to local streams, and this excess water moves southeastward through the aquifer.



Note: 1.0 foot = 0.3048 meter.

Source: Langley and Marter (1973).

0 600 1200 meters



Figure 3-10. Water table elevation when it was at its highest elevation during the period 1961-1967.

Where the outcrop area is low in elevation, such as along the Savannah River Valley in the northwest sector of the SRP, water naturally discharges from the formation to the river. Under the Savannah River Plant the direction of Tuscaloosa ground-water movement is southwesterly toward the outcrop of this formation in the Savannah River Valley (Figure F-25). The Ellenton Formation, which lies above the Tuscaloosa, is apparently hydraulically connected to the Tuscaloosa Formation, and its flow pattern is probably similar.

At the Savannah River Plant, the recharge of the Congaree is from offsite areas and from infiltration of precipitation; the higher formations at the Plant are recharged from infiltration of precipitation (about 40 centimeters per year) (Root, 1983). However, discharge into Upper Three Runs Creek and the Savannah River has a dominant effect on Congaree ground-water flow paths. As discussed in Section 3.4.2.1, the energy levels (heads) in the Congaree are lower than those in the Tuscaloosa over much of Savannah River Plant, precluding any downward infiltration in these areas. TC

On a regional basis, the dissecting creeks divide the ground water in the Congaree and higher formations into discrete or compartmentalized subunits. Depending on the depth of dissection, ground water is confined to its own subunit. Even though the hydraulic characteristics of the formations may be similar throughout the area, each subunit has its own natural recharge and discharge areas. The directions of ground-water flow within the Congaree Formation are shown in Figure F-26.

In the central part of Savannah River Plant, the only stream that cuts into the Congaree is Upper Three Runs Creek. The McBean is incised by Upper Three Runs Creek, several of its larger tributaries, Four Mile Creek, Pen Branch, and Steel Creek. Thus, ground water that enters the McBean Formation over much of the interior of Savannah River Plant is restricted in its connection with other subunits of the McBean because of stream incision.

At Savannah River Plant, the water table is commonly within the Barnwell Formation, although in the creek valleys it successively occupies positions in the lower formations. The surface drainage and topography strongly influence the water-table flow path at any point. Even small tributaries to the larger creeks cause depressions in the water table, diverting ground-water flow towards them. The Hawthorn Formation, which is perhaps the most extensive surficial deposit in this region, is usually unsaturated because of its high permeability. Its flow paths are predominantly vertical, with only short horizontal paths.

Flow pathways within each of the Savannah River Plant areas potentially impacted by L-Reactor operation are summarized in Table 3-9. These include other SRP areas that will support the operation of L-Reactor and, therefore, might be affected by increased support activity. Only in M-Area is there significant potential for water table discharges to reach the major regional aquifer (the Tuscaloosa). A more detailed discussion of site-specific aquifer characteristics, including potentiometric contours and flow paths, is included in Appendix F.

In some localities, drawdown from pumping water production wells in the Tuscaloosa Formation might reduce its water level below that of the Congaree. Thus in a small local area, water could theoretically move from the Congaree

Table 3-9. Flow paths at L-affected areas

Area	Water-table discharge
L-Area	Steel Creek, Pen Branch
L-Area seepage and retention basin	Steel Creek
F- and H-Separation Area	Four Mile Creek, Upper Three Runs Creek
Burial grounds	Four Mile Creek, Upper Three Runs Creek
Central shops	Four Mile Creek, Pen Branch
M-Area	Tim's Branch, Savannah River swamps, Hollow Creek (northwest of SRP), vertically

TE| through the Ellenton into the Tuscaloosa. However, such areas do not underlie L-, K-, and F-Area seepage basins and the burial grounds or central shops.

3.4.2.3 Ground-water quality

The water in the Coastal Plain sediments tends to be of good quality, suitable for industrial and municipal use with minimal treatment. It is generally soft, slightly acidic, and low in dissolved and suspended solids. Appendix F contains a detailed description of the ground-water quality in the vicinity of the various areas of Savannah River Plant that will be affected by L-Reactor operation.

In December 1983, the computerized Well Data File (WDF) contained records for 6404 wells and borings. The WDF provides a central source of information on well and boring construction, geology, and water quality. As many as 66 variables can be entered for each well. There are currently 620 monitoring wells and 70 production wells in the WDF. The remaining records are for engineering and test borings, grout wells, and about 600 old wells, the exact location and status of which are unknown (locations are known within 100 meters).

EL-25

Based on pre-SRP well-drilling practices, many of these old wells are believed to have been shallow hand-dug domestic wells. Some probably penetrated the Tuscaloosa, including some drilled flowing wells discovered on SRP in the Savannah River valley. Any open holes, rusted-out casings, or otherwise defective wells can provide a direct route for contaminated surface water or shallow ground water to deeper aquifers, even the Tuscaloosa. Contamination of lower aquifers cannot occur from flowing wells. No hand-dug or abandoned wells are known to exist at or adjacent to L-Reactor or the waste disposal sites of any of its support facilities. In addition, no contamination of the Tuscaloosa aquifer by radionuclides and chlorinated hydrocarbons has been noted in the central portion of the SRP. Contamination of well water by chlorinated hydrocarbons from A-Area wells producing from the Tuscaloosa was confirmed earlier in 1983; these hydrocarbons were used as degreasers in M-Area. The contamination appears to

have resulted from chlorinated hydrocarbons that entered the well annuli from the contaminated, shallow (Tertiary) aquifer in A- and M-Areas, and not from any generalized contamination, of the Tuscaloosa aquifer itself. Additional details are provided in Section 5.1.1.2, Appendix F, and Du Pont (1983c). EL-25

3.4.2.4 Ground-water use

Most municipal and industrial water supplies in Aiken County are developed from the Tuscaloosa Formation, which occurs at shallower depths as the Fall Line is approached. Domestic water supplies in Aiken County are primarily developed from the Barnwell, McBean, and Congaree Formations. In Barnwell and Allendale Counties (Figure 3-4), the Tuscaloosa Formation occurs at increasingly greater depths; some municipal users are therefore supplied from the shallower Congaree and McBean Formations or from their limestone equivalent. In these counties, domestic supplies are developed from the Barnwell and McBean Formations.

Forty-four municipalities and industries within 32 kilometers of the center of Savannah River Plant that presently use more than 18.9 cubic meters per day from ground-water sources have been identified. Total pumpage for these users is about 106,300 cubic meters per day. The locations of these users are shown in Figure F-25; pertinent data are listed in Appendix F, Tables F-8 through F-10. TC

Twenty municipal users were identified, as shown in Table F-8. Talatha community, the municipal user nearest to the center of Savannah River Plant (about 11 kilometers away) uses about 150 cubic meters per day. The largest municipal user is the town of Barnwell, about 26 kilometers away; it uses 15,140 cubic meters per day, some of which is supplied to local industry.

Twenty-four industrial users were identified (refer to Appendix F). Total industrial pumpage from the Tuscaloosa Formation is about 67,300 cubic meters per day. This includes 13 users on the Savannah River Plant. TC

Of the total municipal pumpage of 39,000 cubic meters per day, at least 23,500 cubic meters is from Tuscaloosa Formation and 15,000 cubic meters is from the Congaree Formation. TC

In addition to the large municipal and industrial users, 25 small communities and mobile home parks, 4 schools, and 11 small commercial interests are listed in the files of the South Carolina Department of Health and Environmental Control as users of ground water. Wells serving these and other miscellaneous users are generally equipped with pumps with capacities from 54 to 325 cubic meters per day and do not draw large quantities of water. Most wells draw from shallow aquifers. The total withdrawal for these 40 users is estimated to be about 1000 cubic meters per day. In addition to the municipal and industrial users, there are a number of domestic wells near the Savannah River Plant; many of these wells also draw from the shallow aquifers. Two South Carolina State Parks are within a 30-kilometer radius of the center of Savannah River Plant: Aiken State Park, with seven wells, and Barnwell State Park, with two wells. The Edisto Experimental Station at Blackville pumps an average of 70 cubic meters per day from the Congaree Formation. Several shallow wells produce small quantities of water for guardhouses at the Savannah River Plant. TC

3.4.2.5 Relationship of ground-water use to water levels

Hydrographs of five Tuscaloosa wells and one Ellenton well are shown in Figure 3-11. Five of these wells are located at the Savannah River Plant. The sixth well, AK-183, is located 29 kilometers northwest of the center of SRP in the Tuscaloosa outcrop area and is not influenced by pumpage in the vicinity of SRP. The winter (December, January, and February) precipitation is plotted at the top of Figure 3-11; precipitation during these months is the principal source of ground-water recharge. An exception occurred in the summer of 1964, when, due to abundant precipitation (about twice the mean), recharge continued throughout the summer. As a result, record high-water levels occurred in 1965 and 1966. A low in winter precipitation occurred in 1968, and this resulted in low water levels in 1970. Generally high Tuscaloosa water levels occurred in 1974, but from then until 1982 Tuscaloosa water levels declined. From 1972 to 1981, there was a general decline in the winter precipitation, which might partially account for the declining water levels, as shown by wells AK-183 and P7A. However, since 1975, SRP pumping has increased by about 80 percent, from 14.9 to 27.0 cubic meters per minute.

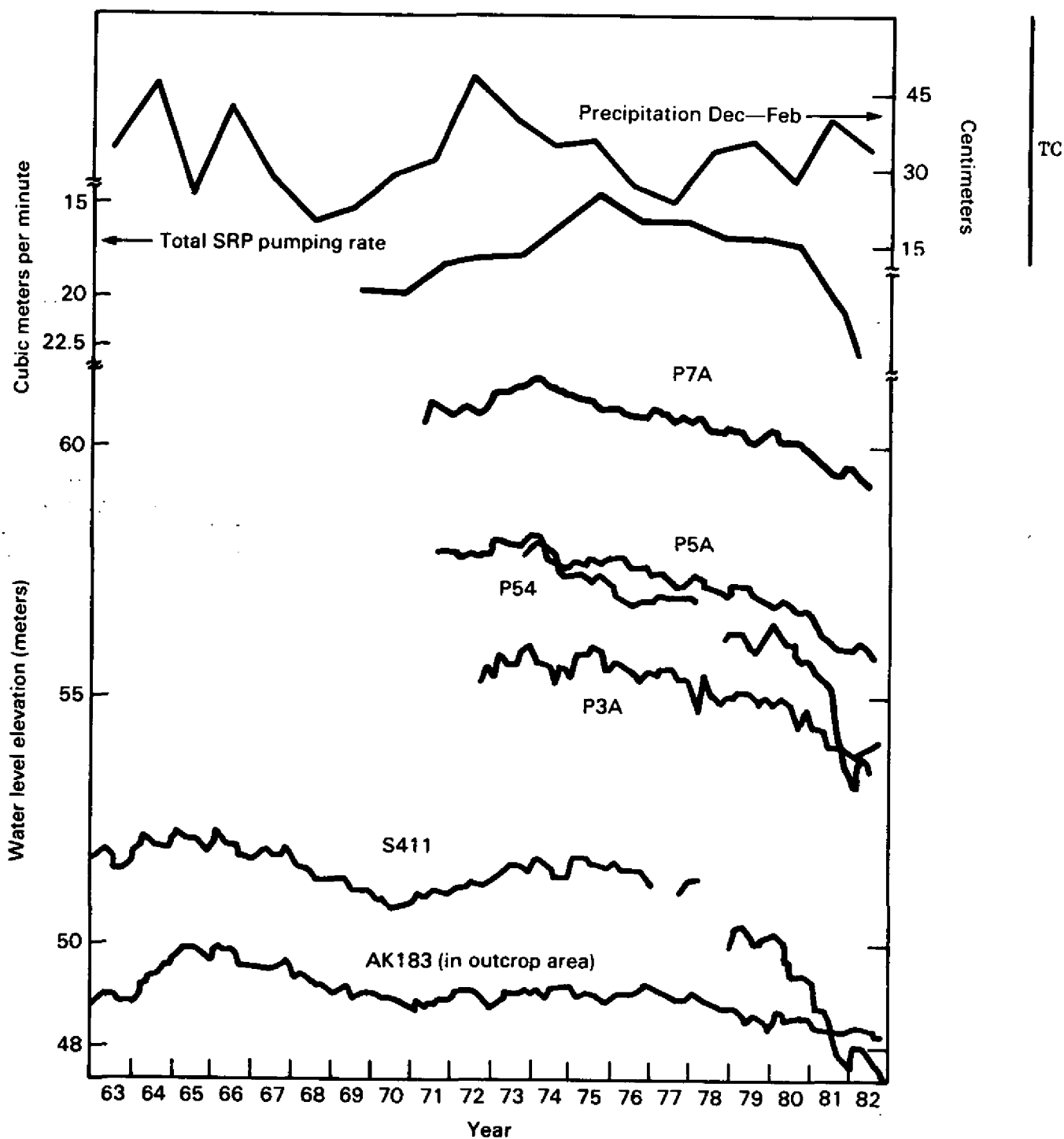
Figure 3-11 shows the total SRP pumping rate (the highest rates are plotted toward the bottom of the Figure to facilitate a comparison of pumping rates and water levels in monitoring wells). Calculations show that the decline in water levels at monitoring wells P7A, P54, and P3A is related primarily to increased ground-water withdrawal at SRP. The drawdowns at these wells reflect adjustments in equilibrium levels rather than aquifer depletion (i.e., withdrawals and flow from an area exceed the ground-water flux into the area). Near-equilibrium water levels are expected to occur quickly (within 100 days) in response to changes in pumping rates (Mayer et al., 1973).

The current (1983) estimate of the total pumpage from the Tuscaloosa Formation within 32 kilometers of the Savannah River Plant is 63 cubic meters per minute (Figure F-25). Usage within the Marine and Routt (1975) ground-water-flux study area (Figure F-31) is currently about 38.5 cubic meters per minute (11.5 from offplant users and 27 from SRP), and should not exceed the natural ground-water flux, which is conservatively estimated to be 51 cubic meters per minute through the study area. When the F-Area powerhouse is placed in standby status in September 1984, the withdrawal of ground water in F-Area is expected to decrease from 6.44 to 3.41 cubic meters per minute. At that time, the projected usage in the study area will be 35.5 cubic meters per minute.

Ground-water withdrawal in A-Area might decrease in August 1984, when the production air stripper is placed in service in M-Area (see Section F.6). Wastewater from the stripper (about 1.1 cubic meters per minute) will be used in the A-Area powerhouse to augment its process-water requirements.

Siple (1967) indicated that withdrawals from the Tuscaloosa at SRP could reach 37.8 cubic meters per minute without exceeding allowable drawdown in existing (1960) production wells. Potentially, the aquifer could produce more water if well fields were better designed. In 1960, the SRP pumpage from the Tuscaloosa was about 18.9 cubic meters per minute (Siple, 1967).

As noted in Section F.4.2, the best estimate of the flux when the model was run in 1974 was 110 cubic meters per minute; this value is now conservatively estimated to be 51 cubic meters per minute. However, incremental pumpage since



Note: Well S411 is producing from the Ellenton Formation, the remaining wells are producing from the Tuscaloosa Formation.

Source: Du Pont (1983c).

Figure 3-11. Hydrographs of Tuscaloosa and Ellenton wells.

the model study was performed might be enough to affect local water levels as new equilibrium levels are established.

AW-1,
EL-15

The decline of water levels in the Tuscaloosa Formation since the mid-1970s has reduced the head reversal at the Congaree Formation that occurs southeast of Upper Three Runs Creek. The upward head differential has declined at a rate of about 0.16 meter per year over the last 10 years, primarily because of increased SRP pumping from the Tuscaloosa. The map of the head difference between the Tuscaloosa and Congaree Formations at Savannah River Plant (Figure 3-9) shows that in 1982 the head reversal was still a general situation in the Savannah and Upper Three Runs Creek valleys.

To illustrate the 1982 vertical head relationship in the central part of the Savannah River Plant, Figure 3-8 compares water levels measured in 1972 with water levels measured on November 7, 1982. Heads in the Barnwell, McBean, and Congaree in 1982 were from 1.0 to 1.5 meters below the 1972 level, but the Tuscaloosa water levels were 2.5 to 3.5 meters below the 1972 level. Even though the upward head differential between the Congaree and the Tuscaloosa Formations was still present, it was reduced. Closer to the Savannah River, the current head differential is about 9 meters, as shown in Figure 3-9.

TC

As water is pumped from an aquifer, the water level in the vicinity of the well must be depressed. The amount of head depression to obtain a given pumping rate depends on the transmissivity of the aquifer. The transmissivity of the Tuscaloosa is very high (i.e., a median value of 1366 cubic meters per day per meter at Savannah River Plant). Thus the cones of depression at the pumping centers for the Tuscaloosa are not areally extensive or very deep. The drawdowns in the vicinity of most 3.5- to 4.0-cubic-meter-per-minute wells in the Tuscaloosa are about 6 to 12 meters. During a pumping test at the Barnwell Nuclear Fuel Plant (Mayer et al., 1973), water was withdrawn from the Tuscaloosa for 60 days at a rate of 10,900 cubic meters per day. A drawdown of about 0.15 meter was observed at SRP monitoring well P54, which is about 9 kilometers from the pumping well.

EL-12

Even though these cones of water-level depression are not areally extensive, drawdowns of 6 to 12 meters are adequate to negate the upward head differential between the Congaree and Tuscaloosa Formations where it exists (see Sections 4.1.1.3, 5.1.1.4, and F.4.3). In areas where a downward head differential exists, such as M-Area, the drawdowns increase the natural downward head differential in the area immediately around the pumping wells.

TC

In South Carolina, the direction of ground-water flow in the Tuscaloosa and Congaree Formations is from offsite areas through the SRP to the Savannah River. Similarly, in Georgia the ground-water flow in these formations is toward the river (Figures F-25 and F-26).

3.5 METEOROLOGY AND CLIMATOLOGY

The description of the meteorology of Savannah River Plant (SRP) and of the L-Reactor area is based on data collected at the Savannah River Plant and at

Bush Field, Augusta, Georgia (Du Pont, 1980c, 1982a; NOAA, 1981). Meteorological data tapes for 1975 through 1979 from the onsite meteorological program provided additional data for this analysis.

3.5.1 Regional climatology

The Savannah River Plant has a temperate climate, with mild winters and long summers. The region is subject to continental influences, but it is protected from the more severe winters in the Tennessee Valley by the Blue Ridge Mountains to the north and northwest. The SRP site and the surrounding area are characterized by gently rolling hills with no unusual topographical features that would have a significant influence on the general climate.

Winters are mild and although cold weather usually lasts from late November to late March, less than one-third of the days have a minimum temperature below freezing.

3.5.2 Local meteorology

3.5.2.1 SRP meteorology data system

Meteorological data are collected from a system of seven towers located adjacent to each production area on the plant site and from the WJBF-TV tower located about 15 kilometers northwest of the SRP boundary. The seven towers are instrumented at the stack height of 61 meters with vector vanes designed for turbulence measurements (Kern and Mueller, 1979). The TV tower is instrumented at seven levels (Garrett and Hoel, 1982) with bivanes and fast-response cup anemometers to provide the same type of information as that received from the SRP towers (Kern and Mueller, 1979). Platinum resistance thermometers at each of eight levels on the TV tower provide temperature information in the lowest 300 meters of the atmosphere.

The data measured by this tower system are received in the Weather Center Analysis Laboratory (WCAL) by the PDP 11/40 (Digital Equipment Corporation) minicomputer. The latest two weeks of averaged data are also kept on the computer and made available to the VAX 11/780 (Digital Equipment Corporation) super minicomputer for use with various atmospheric transport and dispersion models.

The data collected from the SRP tower system and the WJBF-TV tower are used for real-time emergency response applications. Quality assurance inspections of meteorological data summaries generated hourly by the VAX 11/780 are routinely conducted. Regular inspection of the data summaries allows early detection of major system malfunctions so that necessary repairs can be made on a timely basis.

Automated quality assurance is incorporated into the system through the use of a quality control computer code (Pendergast, 1980). For each variable of the SRP tower data, a spatial average is calculated, as is the deviation of individual values from the spatial average. Deviations larger than the expected standard deviation of the variable indicate that the variable value is in error,

and it is replaced with the new spatial average calculated without the erroneous value. Quality control of the WJBF-TV tower data is accomplished in the same manner after first being adjusted, using standard procedures, to the 61-meter SRP tower height. After corrections are made, data are adjusted back to the original heights.

In addition to the tower data, daily records consisting of maximum and minimum temperatures, rainfall, and continuous measurements of temperature, relative humidity, and pressure are kept. Rain gauges are also located at various locations on the SRP site.

An Echosonde doppler acoustic sounder has also been used and is available to provide real-time information on vertical mixing in the lowest 1 kilometer of the atmosphere (i.e., information on thermals, inversions, and depth of the mixed layer).

Regional and national meteorological data are available in the WCAL through the National Weather Service's Automated Field Operations and Service (AFOS) minicomputer system. Data on the AFOS system are available from any point within the AFOS network and can be received in either alphanumeric or graphic display form.

3.5.2.2 Temperature and humidity

Table 3-10 shows the average and extreme temperatures recorded for the Savannah River Plant. The annual average temperature at Savannah River Plant is 18°C. The monthly average temperature ranges from 7°C in January to 27°C in July (see Table 3-10). The extreme temperatures observed at the SRP site are -16°C and 41°C. The Augusta, Georgia, long-term temperature data are in agreement with the SRP data.

The length of the growing season for the Augusta area is normally 241 days, with the first freeze on November 12 and the last freeze on March 16. Freezing temperatures have been observed, however, as early as October 17 and as late as April 21.

The annual average daily relative humidity ranges from 43 percent to 90 percent for Savannah River Plant.

3.5.2.3 Average wind speed and direction

The average wind speed measured in Augusta from 1951 to 1981 was 3.0 meters per second. The average wind speed recorded at a height of 10 meters on the WJBF-TV tower near Beech Island, about 15 kilometers northwest of the SRP boundary, was 2.5 meters per second from 1976 to 1977. The average monthly wind speed for Augusta, Georgia, is shown in Table 3-11 along with the prevailing wind direction for each month. The monthly and annual average wind speeds for three levels of the television tower are also shown. Calms and wind speeds below 2 meters per second at the 62-meter height occur 15 percent of the time at the H-Area tower and 10 percent of the time at the K-Area tower.

Table 3-10. Average and extreme temperatures at Savannah River Plant, 1961-1981

Month	Average temperature (°C)			Extreme temperature (°C)	
	Daily maximum	Daily minimum	Monthly	Record maximum	Record minimum
Jan.	13	2	7	30	-16
Feb.	16	3	9	27	-16
Mar.	20	7	13	32	-12
Apr.	25	12	18	35	0
May	28	16	22	37	5
June	32	19	26	41	9
July	33	21	27	41	14
Aug.	32	21	27	40	13
Sept.	29	18	24	38	5
Oct.	24	12	18	33	-2
Nov.	19	7	13	32	-8
Dec.	15	3	9	28	-11
Year	24	12	18	41	-16

Table 3-11. Average monthly wind speed for Augusta, Georgia, 1951-1981 and WJBF-TV tower, 1966-1977

Month	Mean speed (m/sec)	Prevailing direction	Tower elevation (m)		
			10	36	91
Jan.	3.2	W	3.0	4.5	6.1
Feb.	3.4	WNW	2.9	4.6	5.8
Mar.	3.6	WNW	3.3	4.5	5.9
Apr.	3.4	SE	2.8	4.2	5.4
May	2.9	SE	2.5	3.7	5.0
June	2.8	SE	2.4	4.0	4.8
July	2.6	SE	2.0	3.1	4.4
Aug.	2.5	SE	2.1	3.2	4.3
Sept.	2.5	NE	2.1	3.3	4.7
Oct.	2.6	NW	2.4	4.1	5.6
Nov.	2.8	NW	2.4	4.1	5.6
Dec.	3.0	NW	2.7	4.4	6.3
Annual	3.0	SE	2.5	3.9	5.3

Annual wind direction frequencies for SRP's H- and K-Areas are shown in the transport plots, Figures 3-12 and 3-13. The figures show the percent of time that the wind blows toward each of 16 directions (22.5° sectors). The data presented with these figures indicate the frequency with which the wind was blowing from the indicated direction. The information presented in these figures was

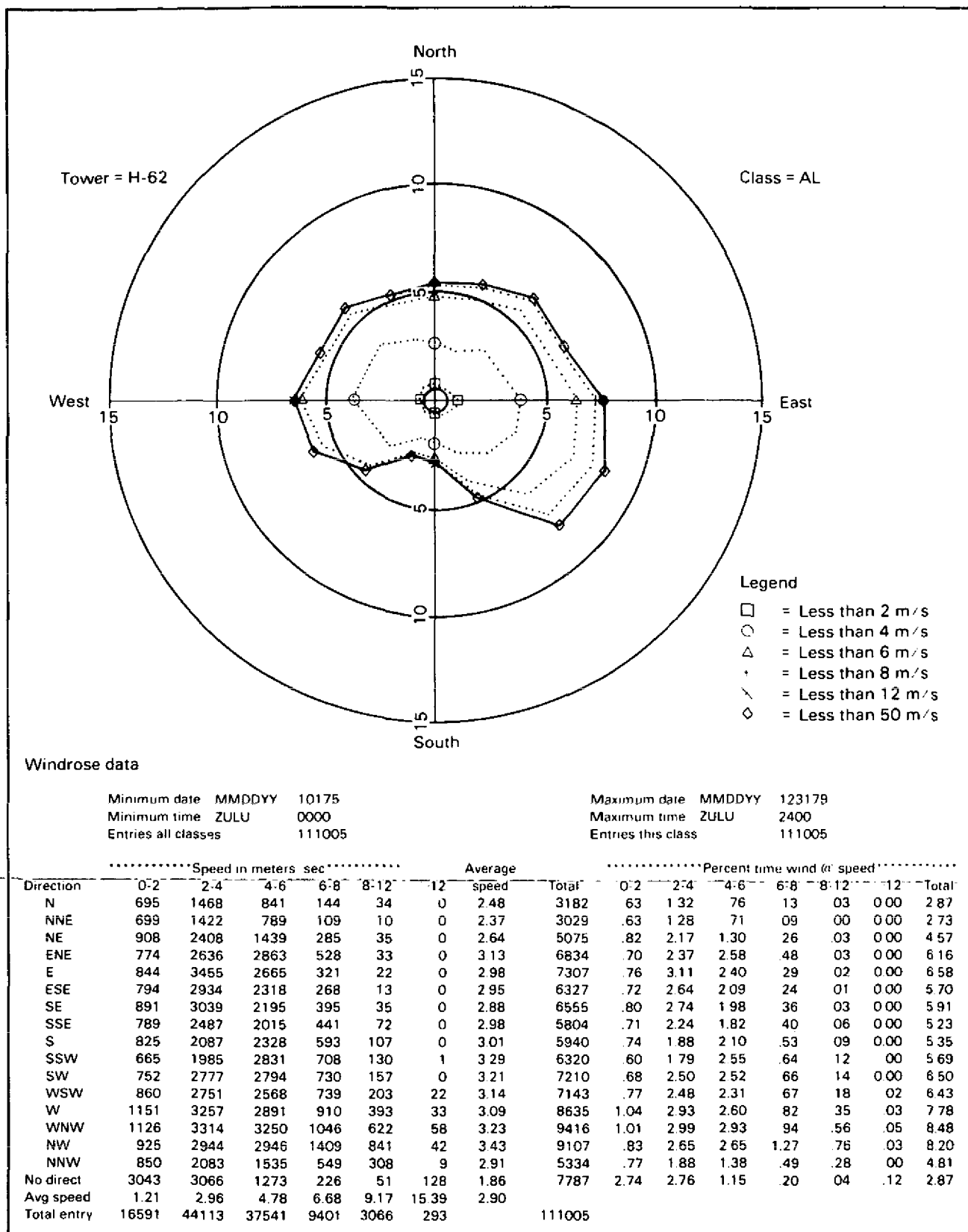


Figure 3-12. Savannah River Plant H-Area wind rose, 1975-1979.

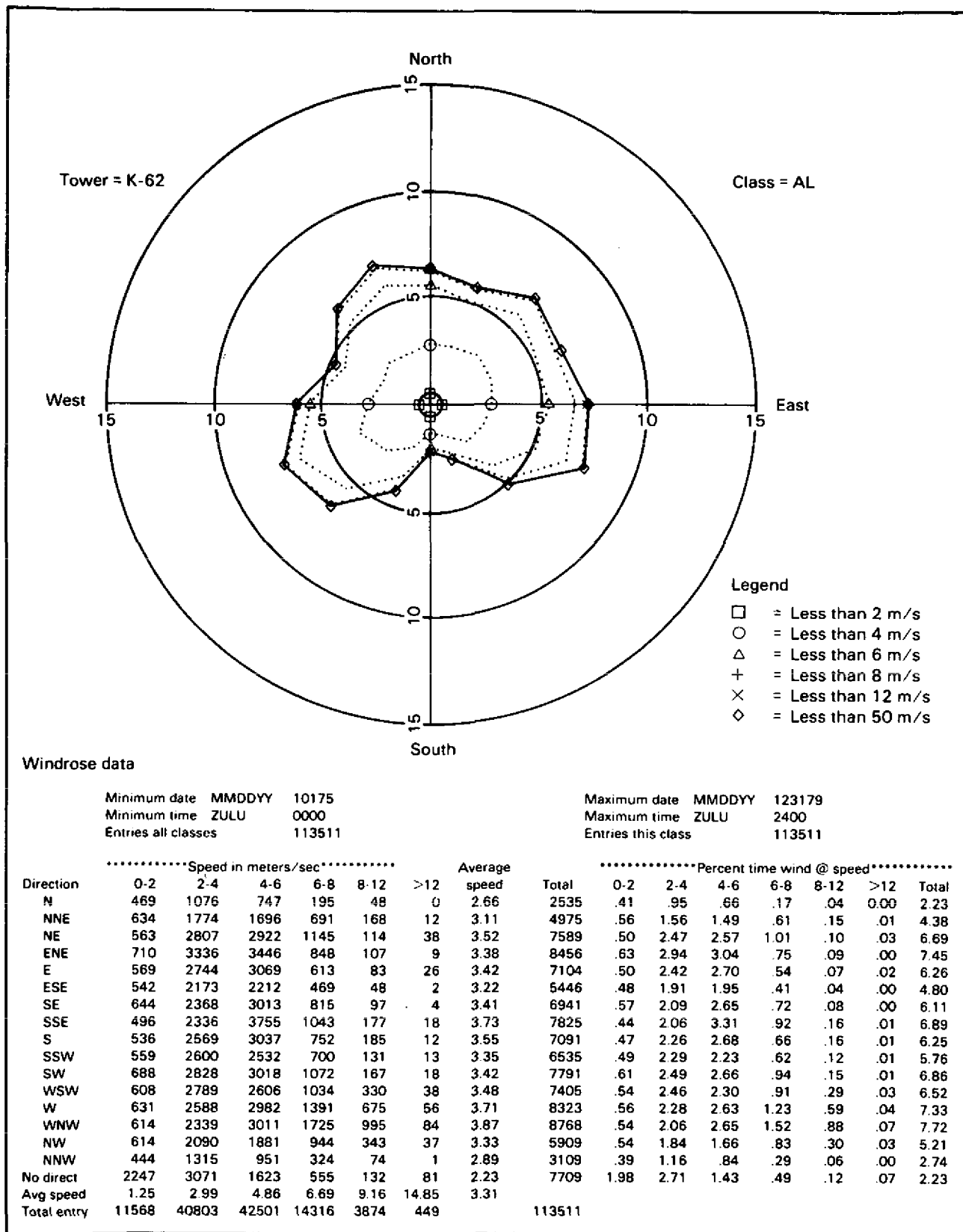


Figure 3-13. Savannah River Plant K-Area wind rose, 1975-1979.

produced from data taken at the 61-meter level (the stack height in most of the production areas) for the H- and K-production areas on the SRP site. Because pollutant dispersion depends on atmospheric stability, wind frequencies are presented for each of seven Pasquill-type stability classes discussed in Appendix B. Annually, the predominant transport is from the west-northwest toward the east-southeast with a secondary maximum from the east-northeast toward the west-southwest. The transport for winter is generally from the northwest toward the southeast. The spring transport is generally from the west toward the east, the summer transport generally toward the southeast through north to northeast, and the autumn transport generally toward the southwest and southeast. Because the pollutant dispersion depends on atmospheric stability, annual wind roses are available for each of seven Pasquill-type stability classes; seasonal wind roses are also available (Hoel, 1983).

3.5.2.4 Precipitation

The average annual rainfall at Savannah River Plant from 1952 through 1978 was about 120 centimeters (Du Pont, 1982a). The average annual rainfall at Augusta from 1941 to 1970 was about 108 centimeters (NOAA, 1981). Table 3-12 lists the means and extremes of precipitation for Savannah River Plant from 1952 to 1982. The maximum monthly precipitation at Savannah River Plant was about 31.6 centimeters, recorded in August 1964. Hourly observations in Augusta show that the intensity of the rainfall is normally less than 1.3 centimeters per hour.

Table 3-12. Precipitation at Savannah River Plant, 1952-1982^a

Month	Monthly precipitation (cm)		
	Maximum	Minimum	Average
Jan.	25.6	2.3	10.7
Feb.	20.3	2.4	10.9
Mar.	28.0	3.8	12.9
Apr.	21.0	1.5	8.9
May	27.9	3.4	10.8
June	27.9	3.9	11.1
July	29.4	2.3	12.5
Aug.	31.6	2.6	11.7
Sept.	22.3	1.4	10.2
Oct.	27.8	0.0	6.2
Nov.	16.5	0.5	5.9
Dec.	24.4	1.2	9.5
Annual			121.3

^aAdapted from Du Pont (1983b).

3.5.3 Severe weather

3.5.3.1 Extreme winds

The strongest winds in the SRP area occur in tornadoes, which can have wind speeds as high as 116 meters per second. The next strongest surface winds occur during hurricanes. During the history of the Savannah River Plant, only Hurricane Gracie, in September 1959, had winds in excess of 34 meters per second. Winter storms with winds as high as 32 meters per second have been recorded occasionally (Du Pont, 1982a). Thunderstorms can generate winds as high as 18 meters per second and even stronger gusts. The fastest 1-minute wind speed recorded at Augusta between 1951 and 1980 was 28 meters per second. Table 3-13 lists the extreme wind speeds for 50- and 100-year return periods for three locations about equally distant from Savannah River Plant (Simiu, Changery, and Filliben, 1979). Section 4.2.2.4 contains return periods from 1-minute wind speeds at Augusta.

Table 3-13. Extreme wind speeds for SRP area^a
(meters per second)

Station	Return period	
	50-year	100-year
Greenville, S.C.	35	38
Macon, Ga.	30	31
Savannah, Ga.	35	39

^aAdapted from Simiu, Changery, and Filliben (1979).

3.5.3.2 Thunderstorms

There is an average of 54 thunderstorm days per year at SRP. The summer thunderstorms occur primarily during the late afternoon and evening; they may be accompanied by strong winds, heavy precipitation, or, less frequently, hail (NOAA, 1981). Summer thunderstorms are due primarily from convective activity resulting from solar heating of the ground and radiational cooling of cloud tops. Thunderstorm activity in the winter months is due mainly to frontal activity.

3.5.3.3 Tornadoes

In the southeastern United States most tornadoes occur in early spring and late summer, with over 50 percent occurring from March through June. In South Carolina, the greatest percentage of tornadoes occurs in April and May, about 20 percent (Pepper and Schubert, 1978) in August and September. The latter are

mainly the result of spawning by hurricanes and waterspouts. One or two tornadoes can be expected in South Carolina during April and May, with one expected in each of the months March, June, July, August, and September (Purvis, 1977).

TE| Weather Bureau records show 278 tornadoes in Georgia over the period 1916-1958 and 258 tornadoes in South Carolina for the period 1950-1980 (Table 3-14). The general direction of travel of confirmed tornado tracks in Georgia and South Carolina is from southwest to northeast.

Table 3-14. Tornado occurrence by month

Month	Georgia (1916-1958)		South Carolina (1950-1980) ^a	
	Number	Percent	Number	Percent
Jan.	24	8.6	6	2.3
Feb.	23	8.3	14	5.4
Mar.	49	17.6	26	10.1
Apr.	93	33.5	40	15.5
May	20	7.2	53	20.5
June	14	5.0	20	7.8
July	5	1.8	17	6.6
Aug.	10	3.6	25	9.7
Sept.	8	2.9	23	8.9
Oct.	2	0.7	8	3.1
Nov.	15	5.4	11	4.3
Dec.	15	5.4	15	5.8
Total	278		258	

^aTornado Frequency Table for South Carolina 1950-1980. Obtained from National Severe Storms Forecast Center, Kansas City, Missouri.

Occasional tornadoes are to be expected in the SRP area. Investigations of tornado damage near Savannah River Plant in 1975 and 1976 indicated wind speeds varying from 45 to 78 meters per second (Du Pont, 1980c).

The annual probability of a tornado striking a building the size of L-Reactor at SRP is discussed in Section 4.2.2.4.

3.5.3.4 Hurricanes and high winds

Thirty-eight hurricanes have caused damage in South Carolina during the 272 years of record (1700 to 1972); the average frequency was one storm every 7 years. The hurricanes affecting South Carolina predominantly occurred during August and September. At the SRP site, 160 kilometers inland, hurricane wind speeds are significantly less than observations along the coast. Winds of 34

meters per second were measured on the 61-meter towers only once during the history of the Savannah River Plant, when Hurricane Gracie passed to the north on September 29, 1959 (Du Pont, 1982a).

3.5.3.5 Precipitation extremes

Heavy precipitation can occur in the SRP area in association with either localized thunderstorms or hurricanes. The maximum 24-hour total was about 15.2 centimeters, which occurred during August 1964 in association with Hurricane Cleo.

3.5.3.6 Hail and ice storms

Hail in association with a severe thunderstorm can be expected to occur in the area about once every 2 years. Damage from such hail is rare. Ice storms caused by freezing rain can be expected about once every 4 years and are usually of short duration (Du Pont, 1982a).

3.5.4 Atmospheric dispersion

3.5.4.1 Atmospheric stability

Transport and dispersion of airborne material are direct functions of air movement. The direction and speed of transport are governed by the large-scale movements (i.e., by general synoptic flow patterns and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. Approximately 25 percent of the time, the atmosphere is unstable in the SRP region; 25 percent of the time, it is neutral; and 50 percent of the time it is stable.

3.5.4.2 Mixing heights and low-level inversions

The mixing height is the level of the atmosphere below which pollutants are easily mixed; it is often equal to the base of an elevated inversion. The depth of the mixed layer at Savannah River Plant has been measured by an acoustic sounder (Schubert, 1975). The acoustic data indicate that, as the day progresses, the mixing height rises beyond the 1000-meter range of the sounder.

An analysis of 5 years of upper-air meteorological data recorded at several stations in the SRP area (Holzworth, 1972) provides further mixing-height information. The average afternoon mixing height is about 1005 meters in the winter, 1700 meters in the spring, 1890 meters in the summer, and 1400 meters in the autumn. Mixing heights over the rural SRP site could be expected to be slightly lower.

Temperature inversions (air temperature increases with the height above the ground) inhibit atmospheric turbulence and, hence, are associated with small rates of atmospheric diffusion. Detailed temperature inversion data are available from instruments on the WJBF-TV tower. The 1974 temperature measurements between 3 and 335 meters were analyzed to determine the frequency of occurrence of several categories of temperature structure (Pendergast, 1976). About 30 percent of the time, a temperature inversion extended to or beyond the 3- to 335-meter layer. About 12 percent of the time, there was an elevated inversion with an unstable layer below; this represents the early morning breakup of a nighttime inversion. About 9 percent of the data showed an inversion at the lower levels with an unstable layer above; this represents the transition period between an unstable daytime regime and the onset of a nighttime inversion.

3.5.4.3 Restrictive dilution conditions

The dilution capacity of the atmosphere depends on local wind speed, wind direction variability, mixing depth, and vertical temperature profile. From 1960 to 1970 the SRP area had about 50 forecast-days of high meteorological potential for air pollution (episodes), or an average of about 5 days per year (Holzworth, 1972). Episodes are most frequent in autumn, when large anticyclones, which are characterized by low wind speeds, clear weather, and large-scale temperature inversions, become nearly stationary off the Atlantic coast, affecting much of the eastern United States.

3.5.4.4 Air quality

The South Carolina and Georgia state governments have established air quality sampling networks. The Savannah River Plant operates an onsite sampling network. These networks monitor suspended particulates, sulfur dioxide, and nitrogen dioxide. Ambient concentrations of these pollutants near Savannah River Plant in 1980 were below the local air quality standards in effect at that time.

3.5.4.5 Correlation of predicted to measured offsite airborne radionuclide concentrations

A statistical air pollution model, XOQDOQ, uses joint-frequency data on wind speed, wind direction, and atmospheric stability class to estimate average relative effluent concentrations, X/Q_s , and average relative deposition values, D/Q_s , at specified locations and at standard radial distances for downwind. It is based on a modified Gaussian plume equation which assumes uniform horizontal dispersion over each of 16 sectors and calculates vertical dispersion using curves fitted with polynomials (Sagendorf and Goll, 1977). The mixing height is set to 1000 meters.

Predictions of the model were compared with measurements in air of the inert radioactive gas, krypton-85, which is routinely emitted in small quantities from the chemical separations facilities at Savannah River Plant (Telegadas

et al., 1980). The model predictions were slightly higher than monitored values.

3.6 ECOLOGY

Savannah River Plant (SRP) was approximately one-third forested and the remaining area consisted of cropland when it was acquired by the U.S. Government in 1951. During the past 32 years, forestry management practices, natural succession, and the construction and operation of nuclear reactors and their support facilities have resulted in the ecological complexity and diversity of the site. The Savannah River Plant is one of the most intensively studied environments in this country; results of these studies and environmental studies in Steel Creek, the Savannah River swamp, and the Savannah River are presented in Appendix C.

3.6.1 Terrestrial ecology

3.6.1.1 Soils

Soils are an important component of the environment because they influence the occurrence and distribution of the vegetation, wildlife, and potential land use by man. The distribution of soils of the Steel Creek watershed is shown in Figure C-2. The portion of the watershed depicted here covers approximately 20,000 acres and includes 24 different soil types. The most widely distributed soils of the Steel Creek watershed are Blanton sand (14 percent), Wagram loamy sand (13 percent), Troup sand (12 percent), Orangeburg loamy sand (8 percent), Rembert sandy loam (8 percent), Fuquay loamy sand (7 percent), and Wehadkee loam (7 percent). Streambed soils of Steel Creek consist primarily of Bibb sandy loam; these soils were scoured and eroded during previous reactor operations. The dominant texture of the surficial horizons is loamy sand and sandy loam. Slopes typically range less than 6 percent and most soils are well drained.

3.6.1.2 Vegetation

The Savannah River Plant is near the line that divides the oak-hickory-pine forest and the southern mixed forest (Kuchler, 1964). Consequently, it has species representative of each forest association. In addition, SRP vegetation has been influenced strongly by farming, fire, soil features, and topography; no virgin forest remains in the region (Braun, 1950). Except for the production areas and their support facilities, many previously disturbed areas have been reclaimed by natural plant succession or planted with pine by the U.S. Forest Service.

The operation of L-Reactor will produce impacts on plant communities in two wetland areas: (1) those associated with the Steel Creek corridor from the L-Reactor outfall to the delta, and (2) those associated with the Steel Creek

delta and that portion of the swamp near the confluence of Steel Creek with the Savannah River. The structure and species composition of these areas reflect not only the heterogeneity of the physical environment, but also the impacts of earlier reactor operations. The wetlands, for example, are the culmination of 15 years of natural succession; they are structurally different from the closed canopy of mature cypress and tupelo gum that existed prior to the existence of the SRP (Sharitz, Irwin, and Christy, 1974). The Fish and Wildlife Service has classified these wetlands as Resource Category 2. The designation criteria for this resource category include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

3.6.1.2.1 Steel Creek corridor

The vegetation of the Steel Creek corridor, which is classified as palustrine wetland (Cowardin et al., 1979), varies markedly above the delta (Figure C-3). More than 85 species of plants representing 50 families were listed from this area in the summer of 1981 (Appendix C). This parcel consists of aquatic beds, emergents, scrub-shrub wetland, and forested wetland; the dominant flora of these cover types is described briefly in the following sections (Smith, Sharitz, and Gladden, 1981).

Aquatic bed

The outfall canal of L-Reactor contains open water bordered by persistent herbaceous species and occasional shrubs.

Emergent wetland

Emergent wetland communities consists of both persistent and nonpersistent vegetation. Persistent vegetation is dominated by dense grasses and forbs with scattered low shrubs. Polygonum dominates a single nonpersistent community just north of the Steel Creek delta. This deeply rooted, emergent annual is bordered by persistent herbs, including cattail, burreed, Canada rush, and sugarcane beardgrass.

Scrub-shrub wetland

Two scrub-shrub wetland communities exist in the corridor. One is dominated by a dense canopy of buttonbush and willow. The second covers approximately 24 percent of the floodplain and is dominated by alder, the dominant species on Steel Creek. Beneath these shrubs, blackberry is abundant over a diverse herbaceous flora of false nettle, goldenrod, wapato, jewelweed, cut-grass, knotgrass, and water purslane. The alder community generally borders the steam channels and, for most of the length of Steel Creek, extends nearly across the width of the floodplain.

Forested wetland

Approximately 73 percent of the wetland vegetation from the outfall to the delta consists of broad-leaved deciduous and coniferous/deciduous communities. Nearly half (46 percent) of these wetlands are dominated by wax myrtle and alder. These codominants reach heights of more than 7 meters and grow in dense stands. Willow-dominated communities rank second (13 percent) in vegetative

coverage; they are more common near the mouth of Steel Creek. The herbaceous stratum is sparse. A mixed deciduous/coniferous community codominated by cypress and tupelo occurs just above Road A and also above the Seaboard Coast Line Railroad. This type of community is much more common in the swamp. Many small communities containing a mixture of sweetgum, red maple, and willow occur intermittently below the outfall. Upland arboreal species adjacent to Steel Creek have become established on the more stable sandbars and near bridges and dikes. Also common are tulip tree, sycamore, and various shrubs. The herbaceous flora is diverse.

3.6.1.2.2 Steel Creek delta

The Steel Creek delta contains ten vegetative associations and four zones differentiated by the degree of prior reactor discharges of thermal effluent (refer to Figure C-4). Impacted zones that have experienced structural reductions of the vegetative canopy include deepwater habitats and the deltaic fan. Bottomland hardwoods and deepwater and upland habitats constitute the non-impacted zones. Since the shutdown of L-Reactor in 1968, vegetative recovery has varied according to the hydrologic regime (refer to Figure C-4).

The deltaic fan zone, which was formed by the deposition of sediments at the mouth of Steel Creek, consists of a raised substrate composed primarily of organic and alluvial deposits over sand (Ruby, Rinehart, and Reel, 1981). Measuring approximately 1200 meters by 500 meters, it is stabilized by vegetation. The more successional advanced vegetation stages include (1) broad-leaved deciduous forest (willow), (2) scrub-shrub wetland (buttonbush and willow), and (3) persistent emergent wetland.

The impacted deepwater zone (refer to Figure C-4) extends as an arc on the periphery of the deltaic fan. Most of the trees in this zone were eliminated during earlier thermal discharges. The zone is characterized by scattered cypress, an abundance of stumps bearing shrubs, and submergent and nonpersistent aquatic herbs. The rooted vascular aquatic bed, nonpersistent emergent wetland, mixed forest/scrub-shrub wetland, and mixed scrub-shrub/rooted vascular wetland associations have their best developments here.

The nonimpacted deepwater zone contains mixed deciduous forest that was typical of the swamp before the beginning of thermal discharges. The underlying substrate near the impacted zone is composed of fine particulate material less than 0.5 meter deep (Ruby, Rinehart, and Reel, 1981).

The bottomland hardwood zone generally is flooded in the spring, but not during the growing season. Two types of broad-leaved deciduous forest are found exclusively in this zone: areas dominated by laurel oak that are inundated only during the flood stage; and an area of intermixed overcup oak, water hickory, and water tupelo that might retain standing water until early in the growing season.

Figure C-5 shows the distribution of the principal plant communities of the Steel Creek delta, as determined from 1978 aerial photography and field studies conducted in the summer of 1981; the classification and mapping terminology follow Cowardin et al. (1979), with minor modifications (Smith, Sharitz, and

Gladden, 1981). All categories are termed palustrine, which includes all non-tidal wetlands dominated by trees, shrubs, persistent emergents, or emergent mosses or lichens.

Approximately one-fourth of the delta area is covered by shrub communities dominated by buttonbush and willow. Five habitat types are similar in coverage, and three minor habitat types also occur. Forested areas dominated by cypress and water tupelo border the delta. More than 123 species of plants representing 66 families were listed during the 1981 field studies (Smith, Sharitz, and Gladden, 1981).

Smith, Sharitz, and Gladden (1982b) present another vegetative map of the Steel Creek delta based on more recent (1981) aerial photography and revised ordination analyses. The principal difference between the vegetative maps is that buttonbush and willow shrub communities have expanded into areas previously occupied by emergent grasses and other herbaceous species. Additionally, vegetative cover types have been modified slightly.

3.6.1.2.3 Commercially valuable biota

Commercially valuable plant biota on the Savannah River Plant include approximately 175,000 acres of timber managed by the U.S. Forest Service.

3.6.1.3 Wildlife

TC | The abundance and diversity of wildlife that inhabits the Savannah River Plant reflect the interspersed and heterogeneity of the habitats occurring there. Emphasis has been given to those fauna that inhabit Steel Creek and the Savannah River swamp. No species have been found in the Steel Creek system that have not been found elsewhere on the SRP site.

Amphibians and reptiles

~~Because of its temperate climate and the variety of aquatic habitats, the~~ SRP site contains a diversified and abundant herpetofauna. Species include 17 salamanders, 26 frogs and toads, 10 turtles, 1 crocodilian, 9 lizards, and 31 snakes that have zoogeographic ranges that include the Savannah River Plant (Conant, 1975). The ranges of many other species are peripheral to Savannah River Plant, and they could also occur on SRP lands. Gibbons and Patterson (1978) provide an overview of the herpetofauna, including the abundance and peripheral species.

During field studies conducted in 1981 and 1982, more than 1560 individuals representing 65 species were collected or observed in the Steel Creek area. In the order of decreasing relative abundance, frogs and toads, turtles, and salamanders constituted more than 85 percent of the species. Six habitat types were examined during the surveys: (1) the stream channel below the delta, (2) the stream channel above the delta, (3) the delta, (4) islands, (5) the floodplain, and (6) the swamp forest. Twice as many species were collected on the floodplain as in the other habitats, because of its greater habitat interspersed (Smith, Sharitz, and Gladden, 1981).

Earlier studies (Freeman, 1955; Jenkins and Provost, 1964) indicate that the alligator has always been a resident of the area. Its abundance probably increased greatly after the Savannah River Plant was closed to the public in the early 1950s.

Studies of the American alligator in the Steel Creek ecosystem were begun in 1981 and have included censuses by foot, boat, and air; capture and release; and radiotelemetry (Smith, Sharitz, and Gladden, 1981, 1982a,b). These investigations confirm that alligators have utilized the Steel Creek ecosystem from the L-Reactor outfall to the Steel Creek delta and swamps, including other areas near Steel Creek such as Carolina bays, backwater lagoons, and beaver ponds. The population of alligators in 1981 and 1982 in the Steel Creek ecosystem was estimated to range between 23 and 35 individuals (Smith, Sharitz, and Gladden, 1982b). Sex ratios and size data suggest a higher reproductive potential in Steel Creek than in Par Pond, where nearly 80 percent of the adults are males (Murphy, 1977).

Studies of the wintering behavior and movements of alligators in the Steel Creek ecosystem were initiated in 1981 using radiotelemetry (Smith, Sharitz, and Gladden, 1982a). Generally, it was found that alligators on the Savannah River Plant do not utilize over-wintering dens, but remain active whenever winter temperatures are suitable. Alligators were able to survive with a body temperature as low as 3.3°C (Smith, Sharitz, and Gladden, 1982a), the coldest ever recorded for a free-ranging alligator. Based on radiotelemetric studies using three individuals, alligators moved between the lagoons near S.C. Highway 125. Alligators also utilized the swamp forest below the Steel Creek delta (Smith, Sharitz, and Gladden, 1982b). In 1981, a single alligator nest was located at the edge of the Steel Creek delta, but hatching was unsuccessful. No nests have been located in the Steel Creek system since 1981.

Birds

Birds of the Steel Creek ecosystem were studied in the summer of 1981 at eight locations, using a combination of strip censuses, mist nets, and aerial surveys. A total of 1062 birds representing 59 species were tabulated during the summer survey; these species presumably breed locally.

Active nests of the Bachman's sparrow, parula warbler, and red-headed woodpecker were observed, as were juveniles of 22 other species. The white-eyed vireo was the most abundant species based on all census techniques, followed closely by the Carolina wren (Smith, Sharitz, and Gladden, 1981). The frequency of observation or capture of the other species was relatively similar, and no single species dominated the census results.

Because of the interspersed habitats and isolation from public hunting, the Steel Creek delta and Savannah River swamp provide an important sanctuary for regional waterfowl. Based on ground counts and aerial surveys, nine species of waterfowl have been observed in the Steel Creek delta area. The mallard and wood duck were the most predominant species of water fowl; both extensively utilized the Steel Creek delta for roosting and feeding. The maximum numbers of mallards and wood ducks that have been tabulated on the delta were approximately 1100 and 400, respectively. Comparisons of the use by waterfowl of the Steel Creek delta with the use of Pen Branch, Four Mile Creek, and Beaver Dam Creek showed that (1) in 1982, utilization was highest in the Steel Creek delta,

(2) Pen Branch delta is unattractive to waterfowl during winter, and (3) the Four Mile and Beaver Dam Creek areas periodically provide good waterfowl habitat.

TC | The wood stork, which is an endangered species, uses the Steel Creek delta for feeding grounds. A total of 102 individuals were observed feeding on or near the Steel Creek delta in late June to early July 1983. The maximum number of observations throughout the SRP swamp during this same period was 478 (Smith, Sharitz, and Gladden, 1983). The Savannah River swamp, particularly the deltas of Beaver Dam and Steel Creeks, provide important feeding habitat for wood storks from the Birdsville rookery near Millen, Georgia.

Mammals

The Savannah River Plant includes zoogeographic ranges of more than 40 species of mammals, including the muskrat and black bear, which are known to occur near Steel Creek.

The short-tailed shrew, the least shrew, and the southeastern shrew predominated among the small mammals captured by means of drift fences, pitfall traps, and board transects during the summer of 1981. The Steel Creek delta provides habitat for the rice rat, and probably for the eastern woodrat and the hispid cotton rat. The gray squirrel, the fox squirrel, and the southern flying squirrel were common in the upland and lowland forests along Steel Creek. Large mammals such as the feral pig and the white-tailed deer were common on the Steel Creek floodplain and delta. Other inhabitants of the floodplain and delta included the raccoon, the opossum, and the gray fox. Beaver signs were common along the length of Steel Creek.

3.6.1.4 Endangered and threatened species

TC | Two species that are listed as endangered by the U.S. Fish and Wildlife Service (USDOI, 1983, 1984)--the American alligator and the wood stork--have been identified in the area. No plant species with protective status has been found. No "critical habitat," as defined by the U.S. Fish and Wildlife Service, exists on the Savannah River Plant.

American alligator - Listed federally as endangered (USDOI, 1983), the alligator is common locally and breeds in Par Pond, in the Savannah River swamp (Gibbons and Patterson, 1978; Murphy, 1977), and along Steel Creek. The ecology of this species has been examined intensively on the Savannah River Plant.

AD-12 | Wood stork - The endangered wood stork (USDOI, 1984) forages in the Steel Creek delta. According to recent studies, these birds are from the Birdsville rookery. The Steel Creek delta and other sites in the Savannah River swamp provide important feeding habitat for wood storks from the rookery.

These species and those listed by the State of South Carolina and the U.S. Fish and Wildlife Service as endangered, threatened, or of "special concern" are discussed in greater detail in Appendix C.

3.6.1.5 Commercially and recreationally valuable biota

Although the ecosystems on the SRP site support many populations of game and fish, commercial exploitation is prohibited and recreational use is restricted to controlled hunts of the white-tailed deer and feral hog.

3.6.2 Aquatic ecology

3.6.2.1 Aquatic flora

Approximately 400 species of algae have been discovered in the Savannah River near the Savannah River Plant (Patrick, Cairns, and Roback, 1967). Diatoms predominate the flora; blue-greens are sometimes common upstream from the site due to organic loading from municipal sources. Since 1951, when algae studies began, diversity has decreased, presumably as a result of increased organic loading to the Savannah River (ANSP, 1961; 1974).

Aquatic macrophytes in the river, most of which are rooted, are limited to shallow areas of reduced current and along the shallow margins of tributaries. Eight species of vascular plants have been discovered in the river adjacent to Savannah River Plant, the most abundant being water milfoil, hornwort, alligatorweed, water weed, and duck potato.

In the SRP streams that receive thermal effluents, the flora is sparse, reflecting the influence of high flow and elevated (greater than 40°C) water temperatures. In these streams, thermophilic bacteria and blue-green algae thrive (Gibbons and Sharitz, 1974).

A deepwater zone occurs where the main flow of Steel Creek courses toward the Savannah River. In this area, the vegetation is currently dominated by submergent and emergent macrophytes. Patches of duckweed occupy mats of submerged vascular plants such as hornwort and parrotfeather. Where the water flow is slow moving, smartweed forms dense colonies (Smith, Sharitz, and Gladden, 1981).

3.6.2.2 Aquatic fauna

3.6.2.2.1 Aquatic invertebrates

Shallow areas and quiet backwaters and marshes of the Savannah River near the SRP site support a diverse aquatic invertebrate fauna. However, the bottom substrate of most open portions of the river consists of shifting sand that does not provide the best habitat for bottom-dwelling organisms (Appendix C). A decrease during the 1950s in the total number of invertebrate species occurring in the river has been attributed primarily to the effects of dredging (Patrick, Cairns, and Roback, 1967). The stabilization of the river discharge and the elimination of habitat caused by the reduction in the flooding of backwater areas might have contributed to the decline. Some recovery occurred during the early 1960s, but complete recovery has not taken place. The groups most

affected are those sensitive to the effects of siltation and substrate instability. Mayflies and dragonflies predominated among insect fauna in earlier surveys. In more recent surveys, true flies have been dominant. Results of insect faunal studies conducted during 1972 (ANSP, 1974) indicated substantial organic loading to the river upstream from Savannah River Plant.

An investigation of the aquatic invertebrate communities living on wood substrate and submerged macrophytes in the Steel Creek ecosystem is being conducted by the Savannah River Ecology Laboratory in the upper and lower reaches of the Steel Creek and in the floodplain swamp (Appendix C). Preliminary investigations and current literature show these habitats to be diverse, with high productivity.

During the spring and summer of 1982, macrobenthic drift population studies were conducted in the Savannah River, the pumphouse intake canals, Upper Three Runs Creek, Four Mile Creek, and Steel Creek as part of the Biological Measurement Program (Appendix C). The drift communities were dominated by true-flies (particularly chironomids), which is typical of a riverine system.

Mollusks, such as snails and clams, are an important component of the Savannah River invertebrate community (Patrick, Cairns, and Roback, 1967), but they do not occur in the drift communities, presumably because their relatively high density (weight) prevents them from floating. The Asiatic clam, Corbicula, is found in the Savannah River and larger tributary streams in the vicinity of the SRP.

3.6.2.2.2 Fish

The Savannah River and its associated swamp and tributaries are typical of southeastern coastal plain rivers and streams; they support a diverse fish fauna. Numerous aquatic studies have been conducted during the past 32 years. The results of these investigations are summarized in Appendix C. The diversity and abundance of fish in the thermally affected streams are high only during periods of reactor shutdown (McFarlane, 1976). In addition, the fauna upstream of the thermal effluents is depauperate in both numbers and diversity. With the exception of the mosquitofish, few fish live in the SRP thermal streams when heated effluent is present. During reactor shutdown, the streams return to ambient temperature and are invaded quickly by many fish from adjacent nonthermal areas. The diversity and abundance of species in the headwater tributaries of Four Mile Creek and Pen Branch upstream from reactor thermal effluents are reduced greatly in contrast to comparable areas in Upper Three Runs Creek or Steel Creek (McFarlane, 1976). Collection efforts have revealed that the first- and second-order tributaries of these streams are essentially devoid of fish.

Fish population studies conducted in the Steel Creek swamp system (Appendix C) indicate a high species diversity. Fish of all sizes were collected in the swamp and a wide range of sizes was collected for most species. The collections were representative of both relative abundance and species composition of the swamp fish community. A total of 5313 fish representing 55 species was collected from the Steel Creek river-swamp from November 1981 through July 1982. The high diversity of fish species is the result of the wide array of habitat types and niches available within the creek-swamp environment. The greatest

abundance and diversity of fish occurred in deepwater areas where the tree canopy was eliminated during previous reactor operations, and the vegetation currently is dominated by submergent and emergent macrophytes.

The use of the Steel Creek delta-swamp area by anadromous fish species (e.g., American shad and blueback herring) was minimal during 1982, although some American shad and blueback herring spawned near the mouth of Steel Creek that year. The appearance of American shad in Steel Creek was late and the numbers were quite small. However, it appears that the shad spawning run in the Savannah River was smaller than in previous years. In 1983, the shad and herring spawning runs occurred earlier than in 1982. There was greater utilization of the Steel Creek delta-swamp by adults of the species in 1983 than in 1982. Also, two striped bass were collected in the delta-swamp area in 1983, while none were found the previous year.

The Biological Measurement Program in the Savannah River was initiated in March 1982 (Appendix C). This long-term study focused on fish populations, meroplankton communities, and fish impingement and entrainment. Results of studies completed to date are presented in reports by Environmental and Chemical Sciences, Inc. (ECS, 1983a-c). The program involved meroplankton, electrofishing, and hoopnet collections in the Savannah River, Upper Three Runs Creek, Four Mile Creek, Steel Creek, and at two pumphouse intake canals. Collections were also made of fish impinged on the traveling screens at the three pumphouse intake canals. Additionally, ichthyoplankton samples were collected by the Savannah River Ecology Laboratory (SREL) in the Steel Creek delta and Steel Creek during the 1982 and 1983 spawning runs (Smith, Sharitz, and Gladden, 1983).

The fish larvae collected during the March-through-August-1982 period in the Savannah River were primarily herring and shad, with unidentified minnows and spotted suckers being abundant. Fish eggs collected were primarily American shad. Striped bass and blueback herring eggs were abundant during a short period of time. Peak spawning activity occurred in May. Striped bass spawning, previously not recorded from the central Savannah River area, was noted in May and July. Fifteen sturgeon larvae were also collected; these have been identified as including both the Atlantic and shortnose sturgeon.

In 1983, ichthyoplankton collections were made in the river from March through July. The peak spawning activity again occurred in May. The larvae collected in greatest numbers were species of the clupeid family (i.e., Dorosoma sp., blueback herring, American shad). Larvae of the crappie and various minnows were also abundant. As in 1982, most of the fish eggs collected were American shad. Striped bass eggs and larvae were prevalent in May and June, and a few were also found in April. Ten sturgeon larvae were collected in the river in 1983; four were shortnose sturgeon (in March) and six were Atlantic sturgeon (in April, May, and June).

TC

The 1983 data indicate a trend in the distribution of fish spawning in the river. In general, during February, March, and April, densities of total ichthyoplankton (eggs and larvae combined) were highest in the lower reaches of the river (from River Mile 30 to River Mile 120); they decreased in an upstream direction. May was a transitional month when densities were more uniform throughout the river. During June and July, densities were generally higher in the nearfield (from River Mile 130 to River Mile 157) and upper farfield (from River

TC

Mile 167 to River Mile 187) than in the areas downstream. The trend of generally higher densities nearer the river mouth earlier in the year is probably due to the fact that the lower Savannah River warmed more rapidly than the upper reaches and provided suitable spawning conditions for a longer period of time. However, factors such as the migratory movement of spawning adults might also play a role in these trends.

The intake canals had high densities of larvae and low densities of eggs. The eggs entrained in the canals probably settled to the bottom because of low-flow rates in the canal.

TC

In 1982, Steel Creek and Upper Three Runs Creek contained numerous larvae and were sites for blueback herring spawning. In 1983, the larvae taken in Steel Creek were predominantly minnows, yellow perch, sunfish, and bass. Many blueback herring eggs were also collected. When compared with 19 other creeks that were sampled 10 or more times, Steel Creek ranked eighth in the density of all larval species combined. This creek was distinctive in that minnows and yellow perch represented about 27 and 30 percent, respectively, of the fish larvae collected. In all other streams of similar size, these two species represented no more than about 13 and 7 percent of the total larvae, respectively. In Steel Creek, densities of crappie larvae relative to other species were much lower than in the other large streams sampled.

Much more fish spawning occurred in Four Mile Creek in 1983 than in 1982, apparently because high river levels reversed stream flow enough to allow fish to enter the creek. A high density of larvae, mostly blueback herring, was observed on April 4, 1983. However, similar medium-sized streams that were sampled had higher larval densities and longer spawning periods than Four Mile Creek. Apparently, the elevated water temperature in this stream was a factor that limited spawning.

Ichthyoplankton collections made by SREL in Steel Creek and the Steel Creek delta from February 28 to June 2, 1983 (Smith, Sharitz, and Gladden, 1983), were dominated by yellow perch, brook silversides, blueback herring, and black crappie.

3.6.2.3 Endangered and threatened species

Two species listed as "endangered" by the Federal Government (USDOI, 1983) and/or the State of South Carolina (Forsythe and Ezell, 1979) are known to occur on or in the vicinity of the SRP. These are the shortnosed sturgeon (Federal list) and the brother spike mussel (state list).

TC

The shortnose sturgeon is found only on the east coast of North America in tidal rivers and estuaries. Prior to 1982, this species had not been reported in the middle reaches of the Savannah River in the vicinity of SRP. However, in 1982 and 1983, shortnose sturgeon larvae were collected in the river near the site, indicating that spawning had occurred in this area. The only known occurrence of the brother spike mussel in the Savannah River occurred in 1972, approximately 15 river miles downstream from the mouth of Steel Creek.

3.6.2.4 Commercially and recreationally valuable biota

Although the ecosystems on the SRP site support many populations of game and fish, commercial exploitation is prohibited. The Savannah River supports both commercial and sport fisheries. Most fishing is confined to the marine and brackish waters of the coastal regions of South Carolina and Georgia. The only commercial fish of significance near the Savannah River Plant are the American shad, the channel catfish, and the Atlantic sturgeon. (The commercial catch of American shad from the Savannah River during 1979 was 57,600 kilograms.) These species are exploited to a limited degree by local fishermen.

Sport fishermen are the principal consumers of river fishes, primarily sunfish and crappie. Striped bass are classified as game fish in South Carolina and Georgia (Ulrich et al., 1978).

The Fisheries Section of the Georgia Department of Natural Resources recently published the results of a fisheries study conducted on the Savannah River during the period July 1, 1981, to June 30, 1982 (Hornsby, 1982). Data on fishing effort, harvest, species sought, habitat or location fished, and angler origin were collected from sports fishermen (Appendix C).

Approximately 4600 anglers fish in the freshwater section of the Savannah River. Georgia residents constitute 68.2 percent of these anglers. The anglers fish in both the mainstream (58.2 percent) and oxbows, creeks, and lakes (41.8 percent) of the Savannah River. Freshwater anglers spend the most time (43.8 percent) trying to catch bream (i.e., bluegill, redbreast sunfish, warmouth, redear sunfish, and spotted sunfish). Bream account for 73 percent of the fish caught. Largemouth bass is the next most popular species (38 percent of the time); however, success is low (2.5 percent of the fish caught). About 90,000 kilograms of freshwater fish are harvested from the lower Savannah River annually.

3.7 RADIATION ENVIRONMENT

3.7.1 Sources of environmental radiation

Environmental radiation consists of natural background radiation from cosmic, terrestrial, and internal body sources; medical radiation; radiation from weapons test fallout; radiation from consumer and industrial products; and radiation from nuclear facilities.

Natural radiation contributes about 48 percent of the annual dose of 195 millirem received by an average member of the population within 80 kilometers of the Savannah River Plant. Medical exposure accounts for 47 percent of the annual dose and the combined doses from weapons test fallout, consumer and industrial products, and air travel account for about 5 percent of the dose. Releases of radioactivity to the environment from Savannah River Plant account for less than 0.1 percent of the total annual dose.

External radiation from natural sources comes from cosmic rays and the emissions from natural radioactive ores. It is highly variable with location and altitude.

Internal radiation from natural sources arises primarily from potassium-40, carbon-14, rubidium-87, and daughters of radium-226. The widespread distribution of fertilizers and food, as well as population mobility, have an averaging effect for these long-lived radionuclides that produce the internal dose. It is estimated that the average internal radiation exposure in the United States from natural radioactivity is 28 millirem per year (BEIR III, 1980).

Medical radiation is the largest source of population exposure to man-made radiation in the United States. The average dose to an individual from medical and dental X-rays, prorated* over the total population, was 78.4 millirem per year (BEIR III, 1980). In addition, radiopharmaceuticals administered to patients for diagnostic and therapeutic purposes account for an average annual dose of 13.6 millirem when prorated over the population. To these patient doses must be added the radiation dose to medical and dental personnel (occupational exposure), which amounts to 0.45 millirem per year when prorated over the total population. Thus, the average medical radiation dose in the U.S. population is about 92.5 millirem per year.

Fallout from nuclear weapons tests is a small source of radioactivity in the environment. The large-scale atmospheric tests conducted by the United States and the Soviet Union in 1961 and 1962 introduced radioactive materials into the stratosphere that were later distributed worldwide. A small amount of radioactivity from these tests continues to be deposited. The more recent Chinese and French tests have been sufficient to maintain a relatively constant rate of fallout deposition. The current and past fallout contributes to human exposure through the following:

- External radiation from radioactive material on the earth's surface
- Internal radiation from inhalation of airborne fallout
- Internal radiation from ingestion of food and water contaminated by fallout

Cesium-137 deposited from past nuclear weapons tests is the major source of long-lived external gamma radiation from fallout. Short-lived radionuclides also contribute significantly to external radiation within a few years of major tests but currently contribute little to the dose. The current dose rate from external gamma radiation is estimated to be about 0.9 millirem per year (EPA, 1972).

*Prorating the dose over the population, as used here and in following parts of this section, is a means of arriving at an average dose, which, when multiplied by the population size, produces an estimate of population exposure. It does not mean that every member of the population receives a radiation exposure from these sources.

Most doses from inhalation of fallout are received in the years immediately after exposure. However, doses from strontium-90 and plutonium-239 will be received over a lifetime because of the long residence time of these radionuclides in the body. The annual dose from inhaled fallout radioactivity was estimated to be only 0.04 millirem in 1969 (EPA, 1972) and is currently even lower.

Ingestion of radioactivity in food and water is the largest source of radiation exposure from fallout. It is estimated that this source of exposure was 3.7 millirem per year in 1980, consisting of 0.6 millirem from carbon-14, 0.4 millirem from cesium-137, and 2.7 millirem from strontium-90.

The average annual total-body dose in 1980 from fallout from nuclear weapons tests is estimated to be 4.6 millirem (0.9 from external gamma and 3.7 from ingested radioactivity).

A variety of consumer and industrial products yield ionizing radiation or radioactive materials and therefore cause radiation exposure to the general population. Some of these sources are television sets, luminous-dial watches, airport X-ray inspection systems, smoke detectors, tobacco products, fossil fuels, and building materials. The estimated whole-body dose for the U.S. population from these sources is 4 to 5 millirem per year (BEIR III, 1980). About three-fourths of this dose is from external exposure to naturally occurring radionuclides in building materials.

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Persons who travel by aircraft receive additional exposure from cosmic radiation because at high altitude the atmosphere provides less shielding from this source of radiation. The average annual airline passenger dose is 2.8 millirem, which when prorated over the entire U.S. population amounts to an average dose rate of 0.5 millirem per year (BEIR III, 1980).

3.7.1.1 Environmental radiation levels in the southeastern United States

The contribution of cosmic radiation to natural background dose varies with both latitude and altitude and thus will be unique to a particular location. Sea-level dose rates range from 30 millirem per year in Florida to 45 millirem per year in Alaska; the exposure rate increases to 200 millirem per year at an altitude of about 2400 meters (EPA, 1977). The average unshielded cosmic radiation dose rate in Georgia and South Carolina is 40 millirem per year (EPA, 1972).

Terrestrial gamma radiation (external to the human body) is attributed primarily to gamma-emitting radionuclides in the natural radioactive series derived from uranium and thorium, with some additional contribution from potassium-40. Variation in the distribution of these natural radioactive materials with geologic formations and their inclusion in materials of construction commonly used in urban areas leads to a wide variation with location. The average unshielded external dose rates from this source of exposure are 60 millirem and 70 millirem per year in Georgia and South Carolina, respectively. However, the variation in these States (including the SRP area) ranges from 6 to more than 350 millirem.

Nuclear facilities in an area will also contribute to the environmental radiation level. The growth of nuclear industry and facilities in the southeastern United States (from West Virginia to Florida and from Arkansas to South Carolina) has been rapid, most of it occurring in the 1970s. In this region there were 24 power reactors either operating or licensed to operate in 1981. There were another 34 power reactors under construction and 4 reactors being planned. When all of these are operating, there will be 62 power reactors in the southeastern United States. Typically, the average radiation dose to individuals within 80 kilometers of a nuclear facility is quite low. Data on releases from 46 nuclear power plants operating in 1979 indicate that the average radiation dose within 80 kilometers of a plant was 0.025 millirem per capita (NUREG/CR-2850, PNL-4221, Vol. 1, December 1982).

1F-6 | An airborne radiological survey of the Savannah River marine region was performed in 1975 to establish terrestrial dose equivalent rates (Hayes, 1977). These rates varied from about 0.001 millirem per hour over water to 0.009 millirem per hour at one location on Wassaw Island. In general, the higher rates occurred over beaches, where heavy minerals containing (natural) thorium and uranium occur. Excluding the water areas, the terrestrial rate averages about 0.003 millirem per hour in this area, which is compatible with other Coastal Plain rates of 0.002 to 0.003 millirem per hour and which is about one-half that measured for the Savannah River Plant. The average dose equivalent rate for the Savannah River marine area is about the same as those measured in Galveston, Texas, and Cape Canaveral, Florida, and somewhat less than that in the Los Angeles, California, area. One radiation anomaly defined in this survey was noted on Hutchinson Island, where dredge spoils have been deposited. The cesium-137 concentration of the post-1957 dredge soil sediment ranges from about 0.3 to 2.7 picocuries per gram. About half the cesium-137 in the post-1957 sediment can be attributed to fallout from weapons testing (Marter, 1974).

3.7.1.2 Environmental radiation levels in the vicinity of Savannah River Plant

A summary of the major sources of exposure for the population within 80 kilometers of the Savannah River Plant and for the river-water-consuming population in Beaufort and Jasper Counties, South Carolina, and in Port Wentworth, Georgia, is presented in Table 3-15. Many of the factors such as the internal radionuclide dose and the medical dose are independent of the site. The factors that are site-dependent are discussed below.

The Savannah River Plant and surrounding area lie between latitudes 33°N and 34°N, with an altitude variation between sea level and roughly 300 meters. It has been estimated that the total unshielded dose equivalent from cosmic radiation in the vicinity of Savannah River Plant (80-kilometer radius) is 35 millirem per year, of which 29 millirem per year is from the ionizing component and 6 millirem per year is from neutrons (Langley and Marter, 1973). Shielding by buildings and the body reduces the cosmic radiation dose to about 32 millirem per year, a 10-percent reduction.

Within 80 kilometers of the Savannah River Plant, measured external gamma dose rates range from 6 millirem to 385 millirem per year (Langley and Marter, 1973). A value of 55 millirem per year represents the average unshielded external terrestrial background in the vicinity of the Savannah River Plant.

Table 3-15. Major sources of radiation exposure in the vicinity of Savannah River Plant

Source of exposure	Dose to average individual (mrem/yr)	Percent of exposure
Natural background radiation		
Cosmic radiation	32.0	
External terrestrial gamma	33.0	
Internal	<u>28.0</u>	
Total	93.0	47.6
Medical radiation		
Diagnostic X-rays	78.4	
Radiopharmaceuticals	13.6	
Medical and dental personnel	<u>0.5</u>	
Total	92.5	47.3
Weapons test fallout	4.6	2.4
Consumer and industrial products	4.5	2.3
Air travel	0.5	0.3
Nuclear facilities (other than SRP)	<0.1	<0.1
Savannah River Plant - environmental radioactivity (1980)	<u>0.2</u>	0.1
Grand total	195.3	

Shielding by buildings and the body reduces this terrestrial radiation dose to about 33 millirem per year, a 40-percent reduction.

Atmospheric testing caused 25,600,000 curies of cesium-137 to be deposited on the earth's surface (United Nations, 1977). About 104 millicuries of cesium-137 per square kilometer were deposited in the latitude band (30°N to 40°N) where South Carolina is located. The total resultant deposition was 2850 curies in the 27,400 square kilometers of the Savannah River watershed and 80 curies of cesium-137 in the 780 square kilometers of SRP. The deposited cesium-137 became attached to soil particles and has undergone only slow transport from the watershed. Results from routine health protection monitoring programs indicate that since 1963 about 1 percent of the 2850 curies of cesium-137 deposited on the total Savannah River watershed has been transported down the river (Du Pont, 1983c).

Onsite monitoring conducted by the Health Protection Department of SRP shows that an average of 50 millicuries per square kilometer (1976-1982 average)

of cesium-137 are in the upper 5 centimeters of the soil column. This value is one-half of the amount originally deposited. The difference demonstrates that some of the radiocesium has moved down in the soil column and some has undergone hydrologic transport to the Savannah River.

Releases of radioactive material to the environment from current SRP operations (1978-1980) cause an average dose of about 0.2 millirem per year of operation to the 80-kilometer-radius population and to downstream consumers of Savannah River water (Du Pont, 1980b,d; 1981a).

The only other nuclear facility within 80 kilometers of the Savannah River Plant that has been operational during the operating history of SRP is a low-level waste burial site operated by Chem-Nuclear Systems, Inc., near the east SRP boundary. This facility, which started operation in 1971, releases essentially no radioactivity to the environment (Chem-Nuclear Systems, Inc., 1980), and the population dose from normal operations is negligible. The 80-kilometer-radius population receives an immeasurably small radiation dose from transportation of low-level radioactive waste to the burial site.

3.7.1.3 Radiation levels in and around L-Reactor area

In 1980, radiation-level survey measurements made outside the L-Reactor area perimeter fence yielded an average dose rate of about 66 millirem per year, approximately equal to background. In 1981, radiation survey measurements were made inside the L-Reactor area perimeter fence, but outside the reactor building. These measurements also indicated an exposure rate of about 66 millirem per year. This indicates that only very small amounts of radionuclides, if any, were deposited in the L-Reactor area during its years of operation. Additionally, a radiation survey is made annually along major SRP roads. The most recent survey indicated no significant contamination along any major SRP road, including Road B, which runs next to L-Reactor.

The L-Reactor area low-level liquid seepage basin has been sampled regularly. ~~The basin is now empty, but it is contaminated from releases made dur-~~ ing earlier L-Reactor operations. Table 3-16 lists maximum concentrations measured in the soil of the seepage basin for three radionuclides detected in 1978.

Table 3-16. Radionuclide concentrations
in L-Area seepage basin soil

Radionuclide	Concentration (pCi/g dry weight)
Cobalt-60	12,800
Strontium-90	112
Cesium-137	400

The L-Area oil and chemical pit, which is approximately 70 meters north-east of the L-Reactor seepage basin, received low levels of radioactive oil and chemical waste from 1961 to 1979. This pit is no longer in use; it will not be used when L-Reactor operation is resumed.

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Beginning in May 1981, water from miscellaneous sumps and the disassembly basin in L-Area was released to Steel Creek. The disassembly basin contained small amounts of radionuclides (primarily tritium, cesium-137, and strontium-90) associated with the operation of the L-Reactor in past years. Water in the basin was removed to allow replacement or repair of all underwater equipment prior to reactivation of this facility.

Prior to release of disassembly basin water to Steel Creek, a continuous water sampler was installed in the L-Area effluent canal for routine monitoring of L-Area releases. The sampling location is upstream of the entry of the canal into Steel Creek to ensure that no radioactivity from P-Area is measured. The total amount of activity released from L-Area in 1982 was 68 curies of HTO, 0.11 microcurie of cobalt-60, 0.56 microcurie of cesium-137, and 0.21 microcurie of strontium-89/strontium-90. The average concentrations of radionuclides in the L-Area effluent canal in 1982 were 14 picocuries per liter of tritiated water, 9.3 picocuries per liter of cesium-137, 0.3 picocurie per liter of gross alpha, 5.5 picocuries per liter of strontium-89/strontium-90, and 7.4 picocuries per liter of gross beta.

3.7.2 Steel Creek-Savannah River system

3.7.2.1 Radiocesium

Since 1955, approximately 560 curies of radiocesium have been discharged to onsite streams from Savannah River Plant. Of this total, about 284 curies were released to Steel Creek. Annual releases ranged from about 0.02 curie since 1978 to a maximum of about 53 curies in 1964. The primary source of this radiocesium was leaking failed fuel elements stored in disassembly basins in the P- and L-Areas. Water was released routinely from these basins to maintain the clarity needed for underwater manipulation of irradiated fuel elements, hence the release of radiocesium (with a cesium-134-to-cesium-137 ratio of about 1:20).^{*} A sharp decrease in the release of cesium-137 to Steel Creek occurred in the late 1960s and early 1970s when (1) the P-Reactor area basin was fitted with sand filters and water was demineralized before its release; and (2) the leaking fuel elements were removed to an environmentally safe storage area.

After the radiocesium was discharged from the P- and L-Areas to Steel Creek, it became associated primarily with the silts and clays in the Steel Creek system. Here the sediments and associated cesium-137 were subjected to continued resuspension, transport, and deposition by the flow regime in the creek.

^{*}For convenience, the radiocesium will usually be described as cesium-137, when the presence of both cesium-134 and -137 is implied.

In addition to SRP releases, nuclear weapons testing, since the mid-1940s, has deposited approximately 2850 curies of radiocesium on the Savannah River watershed, including about 80 curies on the Savannah River Plant.

DA-14

The subsections that follow describe radiocesium in Steel Creek and Savannah River sediments, the radiocesium inventory in Steel Creek, cesium-137 in biota, and cesium-137 in water. Appendix D provides more details.

Cesium in sediments

Radiocesium, primarily cesium-137 in Steel Creek, is predominantly associated with the bottom sediments. The principal mechanisms for the association are (1) cation exchange with kaolinite and gibbsite clay minerals; (2) sorption on minerals; and (3) chelation with naturally occurring organic material. A distribution coefficient ($K_d = 3960$) measured for sediments from Four Mile and Steel Creeks (Kiser, 1979) demonstrates the affinity of cesium-137 for the sediments in the Steel Creek system.

Soil cores collected in 1974 at two transects in Steel Creek between Road A and the swamp showed that 69 percent of the radiocesium was located within the upper 20 centimeters of sediment and 86 percent was confined to the upper 40 centimeters. Findings of more extensive detailed coring conducted in 1981 at 12 transects between the Steel Creek delta and P-Reactor generally confirm the 1974 results; about 61 percent of the radiocesium was found in the upper 20 centimeters and 83 percent in the upper 40 centimeters (Du Pont, 1982a; Smith, Sharitz, and Gladden, 1982a). Sediment samples taken in 1981 from the center of the creek had markedly lower radiocesium concentrations than the sediments near the edges of the floodplain. The radiocesium is predominantly associated with smaller soil particles (Tables 3-17 and 3-18).

Table 3-17. Range of cesium-137 concentrations (pCi/g dry weight) of soil types in Steel Creek, 1981

Soil type ^a	Number of samples	Percentage	Concentrations	
			Mean	Standard error
1 (clay)	101	19	137	20
2	108	21	80	16
3	127	24	39	7
4	83	16	55	12
5 (sand)	106	20	17	3

^aSoil samples were graded visually from 1 to 5, according to their "average" particle size; samples with the highest clay content are type 1 and those with the least clay and silt (i.e., predominantly sand) are type 5 (Smith, Sharitz, and Gladden, 1981).

Table 3-18. Mean radiocesium concentration in soils of Steel Creek floodplain by soil particle size^a (picocuries per gram)

Location ^c	Soil type ^b				
	1	2	3	4	5
Above					
L-Reactor	166	105	62	117	43
L-Reactor to					
Road A	171	112	38	36	8
Road A to					
delta	79	46	18	21	9
Delta	219	59	13	24	17

^aData from Smith, Sharitz, and Gladden (1982a).

^bSoil samples were graded visually from 1 to 5, according to their "average" particle size; samples with the highest clay content are type 1 and those with the least clay and silt (i.e., predominantly sand) are type 5 (Smith, Sharitz, and Gladden, 1982a).

^cFigure 3-2 shows the locations of these areas; estimated radiocesium concentration as a function of depth are provided for major Steel Creek sections in Table D-3.

DA-14

Ground-level (at a height of 1 meter) gamma dosimetry measurements were conducted in Steel Creek along the 12 soil-sampling transects, and the results were compared with radiocesium concentrations in 1-meter-long soil cores and vegetation samples (Smith, Sharitz, and Gladden, 1982b). Maximum exposure rates (see Appendix D for details) were found at upstream transects near the sources of the contamination and downstream in the Steel Creek delta area. Mean exposure rates of 0.057 to 0.100 milliroentgen per hour were observed in the transects nearest P- and L-Reactors, and 0.092 milliroentgen per hour were observed in the delta area. In general, the radiocesium content (in picocuries per 0.1 cubic meter) in the surface soils was the most important of four variables for explaining variations in exposure rates. The relative importance of the other variables, plant concentration (picocuries per gram), soil concentration (picocuries per gram) as a function of depth, and soil texture, varied substantially along the length of Steel Creek (Smith, Sharitz, and Gladden, 1982b). According to the gamma exposure rate data, radiocesium concentrations in the Steel Creek system can be characterized as being patchily distributed across the floodplain. Replicate transects within locations (any of the 12 transect locations) show little similarity in either the locations or the magnitudes of the gamma exposure rates.

Soil samples and thermoluminescent dosimeter surveys from 10 transects in the Savannah River swamp (from the SRP boundary to Little Hell Landing) were made between 1974 and 1980. Soil cores collected in 1974 show that about 70 percent of the radiocesium was confined to the upper 6 to 7 centimeters but that the radionuclide was detectable at depths of 25 centimeters (Du Pont, 1982a).

Cesium in Savannah River

Turbulence in the Savannah River generally keeps fine soil particles in suspension. These particles are deposited where the river velocity and turbulence are low (such as inside river bends, downstream from obstructions, in oxbow lakes, and on the floodplain), and where flocculation occurs in the estuary below River Mile 40. Riverbed sediments upstream from Savannah River Plant normally have about 1 picocurie per gram or less of radiocesium (Du Pont, 1982a).

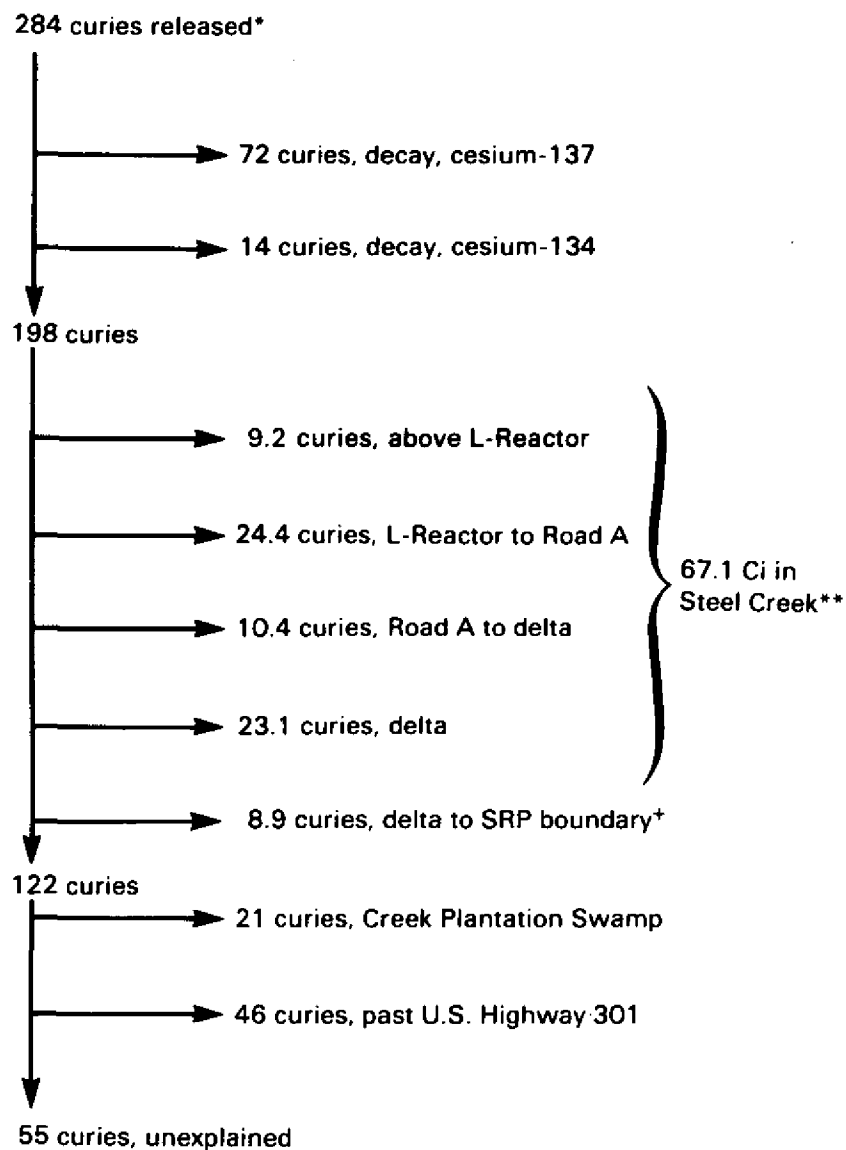
In 1974, riverbed sediments downstream of Savannah River Plant had concentrations of about 2 picocuries per gram near the U.S. Highway 301 bridge and 6.5 picocuries per gram at the South Carolina Highway 119 bridge near Clyo, Georgia. Studies performed in 1978 showed that the radiocesium concentrations were about 0.6 picocurie per gram at the control station above Savannah River Plant and less than 0.8 picocurie per gram at sampling stations between Little Hell Landing and the Highway 301 bridge (Du Pont, 1982a).

Radiocesium inventory

Studies of radiocesium concentration in 1-meter-long soil cores (Smith, Sharitz, and Gladden, 1982a) indicate that about 67 curies of radiocesium currently exist in Steel Creek between the P-Reactor outfall and Steel Creek delta. The distribution of this inventory is shown in Figure 3-14.

Radiocesium was transported, primarily by L-Reactor cooling-water effluent, out of the Steel Creek system to the offsite Creek Plantation swamp and to the Savannah River (Du Pont, 1982a). Approximately 8.9 curies (decay corrected to 1981) are estimated to have been deposited in the area between Steel Creek delta and the SRP boundary, and 21 curies in Creek Plantation swamp between the SRP boundary and Little Hell Landing. Evaluation of the transport in the Savannah River suggests that, given a correction for decay, about 46 curies from Steel Creek were transported past the U.S. Highway 301 bridge near Millhaven, Georgia. Figure 3-14 is a summary diagram of the 1981 radiocesium inventory mass balance. The combination of the known remaining Steel Creek inventory and the inventory in the Savannah River system leaves about 19 percent of the 284 curies of radiocesium released (or 55 curies) unexplained. This fraction of the existing radiocesium inventory could be attributed to the following:

- Less radiocesium released than originally indicated
- A cesium-134-to-cesium-137 ratio greater than 1:20
- Cesium-137 deposited in the river between the mouth of Steel Creek and the Highway 301 bridge
- More cesium-137 from Steel Creek transported past the Highway 301 bridge than indicated by the measurements
- For Steel Creek and Creek Plantation swamp, more cesium-137 below depths of 1 meter



*Released to Steel Creek during 1955-1980.

**Based on soil core measurements.

+ Estimated

Figure 3-14. Cesium-137 mass balance in Steel Creek in 1981 based on soil core and river measurements and decay.

Cesium-137 in biota

Vegetation samples were collected at various times from 1970 to 1981 at 10 transects in Steel Creek between the delta and L-Reactor. Samples were also collected at 10 transects in the Savannah River swamp and Creek Plantation swamp. The average radiocesium concentrations in swamp vegetation are generally less than those in vegetation from the creek. The total radiocesium inventory in Steel Creek vegetation is about 0.4 curie (Du Pont, 1982a).

The concentration of radiocesium in wildlife is generally not high in Steel Creek, the Savannah River swamp, and Creek Plantation swamp; concentrations in Savannah River fish are lower than those measured in fish from Steel Creek (Du Pont, 1982a). Additional details are provided in Appendix D.

Cesium-137 in water

TC | Monitoring in the Savannah River by the Savannah River Plant shows that the concentration of radiocesium in river water has been very low in the past several years. From 1979 through 1982 the mean concentration of cesium-137 at the U.S. Highway 301 bridge was 0.08 picocurie per liter and was near the limit of detection at the control station above the Savannah River Plant (Du Pont, 1980b, 1981a, 1982c, 1983a). For the second quarter of 1983, measurements of the radiocesium in the potable (finished) water at the North Augusta, Beaufort-Jasper, and Cherokee Hill water treatment plants averaged 0.006, 0.028, and 0.033 picocurie per liter, respectively. During this monitoring period, the radiocesium concentrations in the potable water were found to vary inversely with river flow (Kantelo and Milham, 1983). In 1982, the monthly average cesium-137 concentration in Steel Creek at the Cypress Bridge (just upstream from the delta; see Figure D-3) was about 3 picocuries per liter; this concentration is about the same as those measured during the previous 5 years.

In November and December 1981, seven water samples from Steel Creek between Road A and the delta were analyzed for their cesium-137 (and potassium) content (Ribble and Smith, 1983). The concentrations ranged from 3.9 to 7.9 picocuries per liter and had a mean value of 5.3 picocuries per liter (with a mean potassium concentration of 1.0 milligram per liter). About 84 percent of this value was associated with the dissolved fraction and 16 percent with the suspended solid fraction. Similarly, Shure and Gottschalk (1976) found that about 20 percent or less of the cesium-137 in water samples from Lower Three Runs Creek was associated with the suspended solid fraction.

TC | More recently, Hayes (1983) reported the results of cesium-137 measurements in Steel Creek made from April through August 1983. During this period, the average transport of cesium-137 was 3.2 ± 1.5 millicuries per week at Cypress Bridge. On this basis, the annual transport would be about 0.17 ± 0.08 curie per year. These measurements indicated that about half the transported cesium-137 was due to remobilization from the creek floodplain system above L-Reactor.

TC | Hayes (1983) also reported that the water that enters Steel Creek from L-Area, from Meyer's Branch (the principal tributary of Steel Creek), and as local rainfall contained cesium-137 concentrations of less than 1 picocurie per liter. However, the measured cesium-137 concentrations at Cypress Bridge averaged about 3.7 ± 0.6 picocuries per liter during the April through August 1983 study period. Hayes contends that the cesium-137 concentrations are governed by

a reequilibration process between the water and the cesium in the creekbed and floodplain sediments, because he could find no correlation during this period between cesium concentration and creek flow rate, suspended solid or tritium concentrations in Steel Creek water, or rainfall in the area. Hayes concluded that the creekbed and floodplain sediments could support cesium concentrations as high as about 11 picocuries per liter at equilibrium, and that the lower concentrations (3.7 picocuries per liter) were probably due to insufficient time for equilibration between the water and the cesium-laden sediments. The travel time for water from L-Area to Cypress Bridge is less than 1 day.

TC

3.7.2.2 Radiocobalt

Since 1955, 66 curies of radiocobalt (Du Pont, 1983b), formed by neutron activation of stainless steel and dissolved in the fuel element storage basin water, have been discharged to onsite streams. Of this total, approximately 27 curies have been released to Steel Creek. As a result of radioactive decay, a small amount, about 2.1 curies, remains in Steel Creek or Creek Plantation Swamp, or has been transported to the river in a manner similar to radiocesium. Further examination of cobalt has not been performed because the inventories in both Steel Creek and the Savannah River system are significantly less than the bounding cesium inventories (Du Pont, 1983c). Additional details can be found in Appendix D.

3.7.2.3 Radiostrontium

L- and P-Areas have released approximately 0.5 curie of strontium-89 and 40.8 curies of strontium-90 to Steel Creek (Ashley, Zeigler, and Culp, 1982). Because of the short half-life of strontium-89 (50.5 days), no measurable quantities are likely to exist in the creekbed sediments. Strontium-90 has a half-life of about 28 years. About 14.3 curies of strontium-90 have been lost by radioactive decay. According to ERDA (1977) and Marter (1974), another 20.8 curies have been transported to the Savannah River. Thus, about 5.7 curies of strontium-90 might still remain in the sediments of Steel Creek. Soil corings in Steel Creek at Road B and Cypress Bridge and near its mouth have revealed strontium-90 concentrations ranging from 0.11-0.14 picocurie per gram in 1978 to 0.12-0.14 picocurie per gram in 1979. At the SRP control station, strontium-90 concentrations of soil samples were 0.06 picocurie per gram in 1978 and 0.14 picocurie per gram in 1979 (Ashley et al., 1982). These soil coring studies suggest that the inventory might be much less than 5.7 curies. It is not surprising that most of the strontium-90 has been transported from Steel Creek, because the kaolin clay particles of the creekbed sediments have little sorptive capacity for strontium. The distribution coefficient for strontium-90 in SRP kaolinitic soils might be as low as 20 (Oblath et al., 1983), which is at least 35 times less than that for cesium-137.

DA-16

Strontium-90 has been detected slightly above background levels in the sediments of Creek Plantation Swamp. This radionuclide has also been detected in composited swamp vegetation samples at concentrations of a few picocuries per gram (Marter, 1974).

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4 ENVIRONMENTAL CONSEQUENCES

The proposed action is to resume L-Reactor operation as soon as practicable to produce needed defense material (i.e., plutonium). The Department of Energy's (DOE) preferred alternative is to operate L-Reactor after the construction of a 1000-acre lake to cool the reactor's thermal discharge to meet water-quality standards of the State of South Carolina. DOE has changed the preferred alternative it presented in the Draft Environmental Impact Statement (EIS), which was to operate L-Reactor with direct discharge to Steel Creek with subsequent mitigation, as a result of public comment and discussions with regulatory authorities.

The Department of Energy has identified the 1000-acre lake, with modifications of the reactor power levels, as the preferred thermal mitigation alternative following discussions with the South Carolina Department of Health and Environmental Control (SCDHEC) and the U.S. Army Corps of Engineers (COE). This alternative would comply with the State's water-quality standards by assuring the existence of a balanced biological community (balanced indigenous population and balanced biological community are used interchangeably in this EIS) and it could be constructed by the Corps of Engineers in about 6 months. The 1000-acre lake is one of 33 cooling-water alternatives evaluated in the Final EIS; its expected environmental effects were bracketed by the cooling-water alternatives evaluated in the Draft EIS (i.e., a once-through 500-acre lake, a 1300-acre recirculating lake, and modified reactor power operation). The 1000-acre lake is the largest lake possible considering the terrain of the Steel Creek valley that can be constructed by the Corps of Engineers within a single construction season and the smallest lake allowing maximum operational flexibility.

This chapter discusses the potential environmental effects of L-Reactor for normal operation under reference-case assumptions, for postulated accidents, transportation, mitigation alternatives (safety, cooling water, disassembly-basin purge-water disposal, and 186-Basin sediment disposal), decontamination and decommissioning, and safeguards and security. The expected environmental effects of the preferred alternatives are discussed separately in Section 4.5.

4.1 NORMAL L-REACTOR OPERATION

This section characterizes the expected nonradiological and radiological effects due to normal operation of L-Reactor. Nonradiological effects include those that might result from an increased workforce, the withdrawal and discharge of cooling water, the discharge of liquid and atmospheric chemical effluents, and the disposal of solid nonradioactive wastes. This section does not consider cooling-water mitigation measures, which are described in Section 4.4.2; however, it does discuss the effects of direct discharge to Steel Creek, which is referred to as the reference case, to which other alternative cooling-water mitigation measures can be compared. Radiological effects include those that might result from airborne and liquid radionuclide releases, the disposal of radioactive wastes, and the resuspension and transport of radiocesium and cobalt-60 in Steel Creek.

4.1.1 Nonradiological impacts

4.1.1.1 Land use and socioeconomics

Land use

The proposed resumption of L-Reactor operation under the reference case would not alter existing land use on the Savannah River Plant (SRP) site, nor would it require the acquisition or the use of land off the SRP site; therefore, no direct land-use impacts are expected.

TC Four historic sites and one prehistoric site in the Steel Creek terrace and floodplain system have been determined to be eligible for inclusion in the National Register of Historic Places. A mitigation plan has been developed to ensure the preservation of these resources, and the plan has been approved by the South Carolina State Historic Preservation Officer (Du Pont, 1983b). Stage I of this mitigation plan involves monitoring to ensure that the sites would not be directly impacted by L-Reactor operation. This monitoring phase has been ongoing; during cold-flow testing conducted in 1983, erosion of three sites (38BR112, 38BR269, and 38BR286) was observed. Stage II (mitigation) has been implemented and protection of the sites by riprap as specified in the mitigation plan is being accomplished under the guidance of the University of South Carolina Institute of Archeology and Anthropology.

Socioeconomics

Operational employment for L-Reactor, which began in 1981, peaked at about 400 employees in mid-1983 and is expected to decrease to 350 by mid-1984, or about 4 percent of the current workforce at the Savannah River Plant (Du Pont, 1982b). Essentially all the operating workforce for L-Reactor has been hired and resides in the SRP area; therefore, no additional impacts are expected to local communities and services due to in-migrating workers.

L-Reactor operation is expected to have annual total local expenditures on materials and services of approximately \$3 million and a total payroll and overhead expenditure of about \$21 million. These expenditures are expected to result in the creation of about 50 regional job opportunities. In addition, these are expected expenditures to produce an additional direct and indirect income of another \$3 million. The total economic benefit to the SRP region during L-Reactor operation would amount to at least 400 direct and indirect job opportunities, about \$25 million in direct and indirect annual income and payroll, and \$3 million in direct annual expenditures on materials and services.

These contributions to the local economy would help pay for public services directly through income, property, and license taxes and user fees and indirectly through sales taxes on goods and services. The benefits provided by the project would help offset the small increase in demands for local services that it generates.

4.1.1.2 Surface-water usage

Under the reference case (direct discharge to Steel Creek), the once-through cooling-water system, similar to that used during the previous L-Reactor operation, would withdraw about 11 cubic meters per second of water from the Savannah River. This would be less than 4 percent of the average flow and 7 percent of the 7-day, 10-year low flow of 295 and 159 cubic meters per second, respectively. Because little L-Reactor cooling water would be consumed, essentially all water withdrawn from the river would be returned to the river after passing through the L-Reactor heat exchanger and the Steel Creek system. The estimated consumptive water use by L-Reactor is 0.85 cubic meter per second (Neill and Babcock, 1971).

EL-2

Withdrawal of cooling water for L-Reactor operation would affect the aquatic ecology of the Savannah River by (1) the entrainment in the cooling water of aquatic organisms (predominantly fish eggs and larvae) smaller than the screen mesh in the intake system, and (2) the impingement of aquatic organisms (primarily fish) on the intake screens.

Entrainment

An expanded Savannah River aquatic ecology program was initiated in March 1982 to evaluate the impact of the Savannah River Plant, particularly L-Reactor restart, on the Savannah River fisheries (Appendix C). Data from previous studies conducted in 1977 (McFarlane et al., 1978) were also used in this impact analysis (see Appendix C). In general, the projected levels of entrainment and impingement developed from the 1982 investigations are similar to those based on the 1977 results. However, some differences do exist. A discussion of these impacts is given in the following sections.

The analysis of the data obtained in 1983, during the second year of the expanded aquatic ecology program, is still preliminary. However, the 1983 results have been used in certain parts of the impact assessments below.

AY-6

Estimates of the numbers of fish larvae that could be entrained by the cooling water of the L-Reactor and the other SRP installations were obtained in the following manner. The average density of larvae found in the replicate samples taken from the intake canals was multiplied by the total volume of water pumped into the intakes during each 24-hour sampling period. This calculation estimated the total number of larvae that was entrained during each day of sampling. These individual totals were extrapolated for the days when samples were not taken to estimate entrainment numbers for the entire spawning period.

Estimates of the numbers of fish eggs that could be entrained were made in a similar manner. However, densities of eggs found in the samples taken from the river adjacent to the intake canals were used as a basis for the calculations instead of the densities obtained in the canals themselves because samples from the intake canals are believed to underestimate the egg densities; the water velocities in the canals are not sufficient to support drifting semibuoyant eggs. Entrainment in the 3G and 5G intake canals was calculated using the density of eggs immediately upstream from 3G. The egg densities for 1G were calculated as a volume-weighted average of the egg densities in the river upstream from 1G and in Upper Three Runs Creek, because a large portion of the discharge of Upper Three Runs Creek enters the 1G intake canal.

According to the results of the 1982 studies and predicted L-Reactor withdrawal rates, it is estimated that approximately 7.7×10^6 fish eggs and 7.6×10^6 fish larvae would be entrained by the L-Reactor cooling water each year during the spawning season. The corresponding projections based on the 1983 data are 3.8×10^6 eggs and 11.9×10^6 larvae (see Table 4-1). These totals represent approximately 6 percent of the fish eggs and larvae contained in the Savannah River water passing the intake canal during the 1982 spawning season and 3 percent during the 1983 spawning season.

AY-6 Table 4-1 compares the entrainment projections derived from the 1977, 1982, and 1983 ichthyoplankton surveys. In general, the loss estimates from all three studies are similar, although the 1982 estimates of egg entrainment and the 1983 estimates of larval entrainment are somewhat higher than those of the other years. (Appendix C contains data on the relative abundance and species composition of eggs and larvae collected.) This might be due either to differences in collection methods used during the two studies or to natural year-to-year variations in abundance. One of the objectives of the current Savannah River fisheries program is to attempt to determine the cause of these differences.

AY-6 For the impact assessments made in this document, the worst-case situation is assumed and the highest projections of fish egg and larvae entrainment are used (i.e., egg data from 1982 and larval data from 1983). Accordingly, the restart of L-Reactor would result in the entrainment of 7.7×10^6 additional fish eggs and 11.9×10^6 additional fish larvae annually.

Impingement

TC Impingement studies were first performed at SRP in 1977 (McFarlane et al., 1978) and were resumed in March 1982 as part of the expanded Savannah River aquatic ecology program. The results of these investigations indicate that the impingement rate is influenced to some degree by several factors, including the number of pumps in operation, the volume of water pumped, the river water level, the water temperature, and the density and species of fish in the intake canal; only some of these factors will be affected when the L-Reactor begins operation. Accordingly, the estimates of incremental increases in impingement due to L-Reactor should be used for comparative purposes only.

A total of 684 fish representing 35 species was collected during 52 impingement samplings from March 1982 through February 1983 at the 1G, 3G, and 5G pumphouses. The number of fish impinged varied from 0 to 98 in a 24-hour period, with an average of 13.2 fish per sample. This is higher than the impingement estimates from 1977 of 7.3 fish per sample (McFarlane et al., 1978). According to the 1982 data, the restart of L-Reactor would result in an additional 6 fish per day impinged during normal river flow conditions, or a cumulative total of about 19 fish per day for all SRP operations.

AY-6 The data from the 1983 portion of the ongoing impingement studies indicate that more fish were impinged that year than previously. The information for the 12-month period ending August 1983 (the last date for which data are available) was analyzed to evaluate the latest data.

A total of 3604 fish representing 48 species were impinged on the SRP intake screens during ninety-eight 24-hour samples taken between September 1982 and August 1983. The impingement ranged from 0 to 540 fish per day. The weight

Table 4-1. A comparison of ichthyoplankton entrainment for 1977, 1982, and 1983^a

Year	SRP pumphouses			Total	L-Reactor impact ^a	Cumulative impact
	1G	3G	5G			
1977 ^b						
Eggs	--	--	--	6.8 x 10 ⁶	2.9 x 10 ⁶	9.7 x 10 ⁶
Larvae	--	--	--	19.6 x 10 ⁶	8.3 x 10 ⁶	27.9 x 10 ⁶
Total				26.4 x 10 ⁶	11.1 x 10 ⁶	37.5 x 10 ⁶
1982 ^c						
Eggs	8.7 x 10 ⁶	8.2 x 10 ⁶	1.2 x 10 ⁶	18.1 x 10 ⁶	7.7 x 10 ⁶	25.8 x 10 ⁶
Larvae	5.2 x 10 ⁶	12.0 x 10 ⁶	0.7 x 10 ⁶	17.9 x 10 ⁶	7.6 x 10 ⁶	25.5 x 10 ⁶
Total	13.9 x 10 ⁶	20.2 x 10 ⁶	1.9 x 10 ⁶	36.0 x 10 ⁶	15.3 x 10 ⁶	51.3 x 10 ⁶
1983 ^c						
Eggs	4.2 x 10 ⁶	4.1 x 10 ⁶	0.7 x 10 ⁶	9.1 x 10 ⁶	3.8 x 10 ⁶	12.9 x 10 ⁶
Larvae	12.9 x 10 ⁶	13.3 x 10 ⁶	1.8 x 10 ⁶	28.1 x 10 ⁶	11.9 x 10 ⁶	40.0 x 10 ⁶
Total	17.1 x 10 ⁶	17.4 x 10 ⁶	2.5 x 10 ⁶	37.2 x 10 ⁶	15.7 x 10 ⁶	52.9 x 10 ⁶

^aL-Reactor 1982 estimates are calculated using the ratio 11 m³/sec to 26 m³/sec, which is the ratio of estimated L-Reactor cooling-water usage to the average current cooling-water usage. Accordingly, L-Reactor entrainment estimates and cumulative estimates should be used for comparison only because they do not reflect measured cooling-water withdrawal.

^bAdapted from McFarlane et al. (1978); McFarlane (1982).

^cAdapted from Du Pont (1983b).

of fish impinged ranged from 0.1 gram to 22.9 kilograms per day. The total weight of the fish impinged during the entire period was 91.3 kilograms. During this 12-month period, an average of about 37 fish per day were collected in the impingement samples. At this rate, a total of 13,505 fish would be impinged annually.

AY-6 The majority of the fish were in the family Centrarchidae (71 percent) or the family Clupeidae (15 percent). The most common fish, bluespotted sunfish, represented 35 percent (1259) of the total fish collected.

The total number of fish impinged showed a sharp increase in mid-March 1983 and remained high through early May 1983. This high impingement coincided with considerably higher river water levels than those that occurred during the remainder of the sampling year. During the period of high impingement, most species had only slight increases in numbers impinged; however, a sharp increase was observed in the numbers of bluespotted sunfish and pirate perch caught on the screens. Both species generally inhabit slower moving areas of the river, but they could have been driven out by high water.

Figure 4-1 shows the average number of fish impinged at the three intake canals and the Savannah River water levels from March 1982 through August 1983.

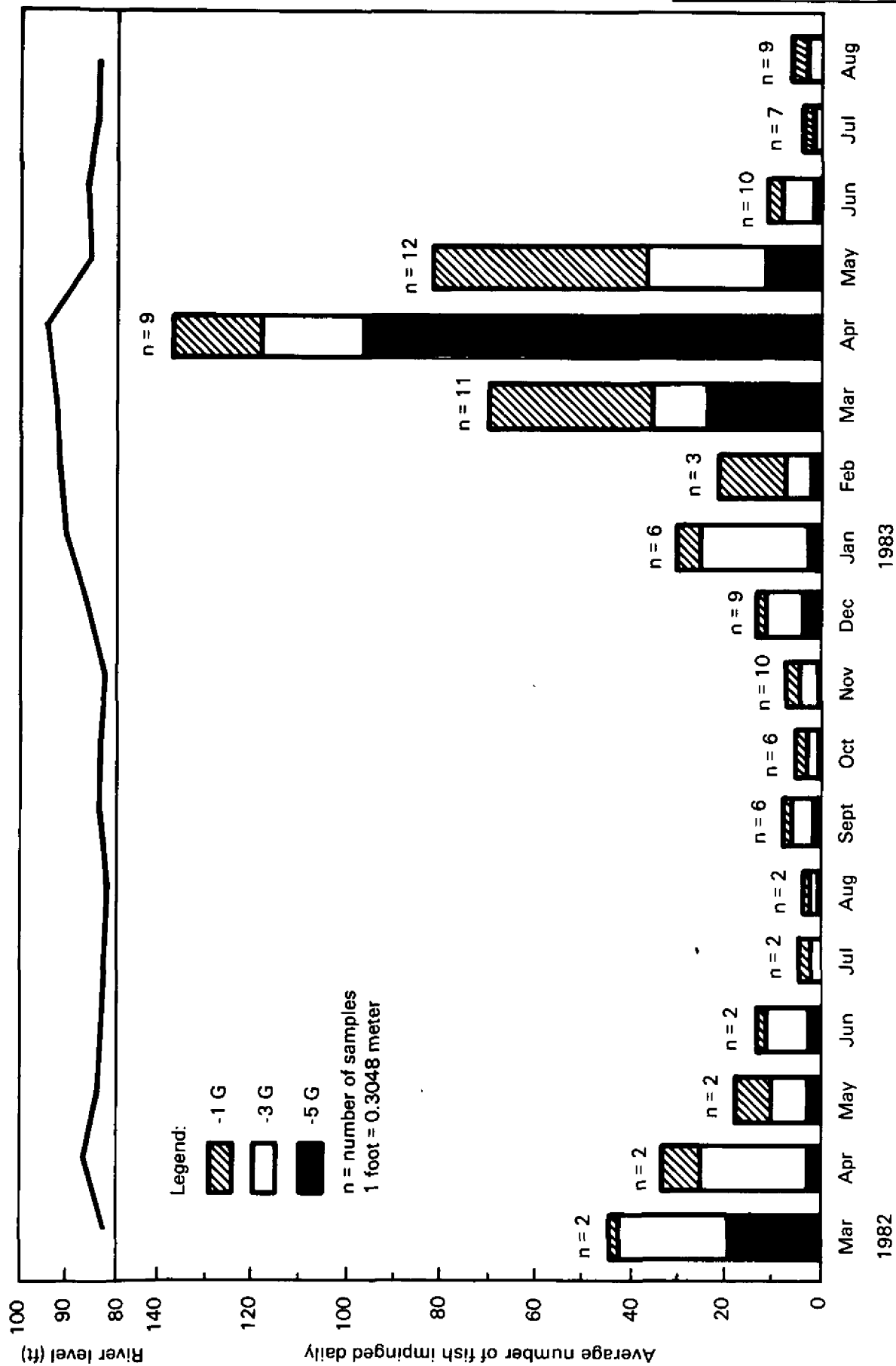
AY-6 It is estimated that, under average conditions (based on 1983 data), an additional 16 fish would be impinged each day due to the restart of L-Reactor, owing to increased withdrawal. An estimated 5840 fish per year could be impinged due to L-Reactor operation.

Surveys of the recreational fishery in the fresh-water portions of the Savannah River indicate that the species caught in greatest numbers by anglers are bream (i.e., bluegill, warmouth, and sunfish), crappie, and catfish (i.e., catfish and bullheads). These species make up about 37 percent of the total number of fish collected during the impingement studies. Using these data, estimates can be made of the numbers of these recreationally important fish that would be lost due to impingement. Table 4-2 summarizes these estimates.

~~The largemouth bass is another important sportfish; it is the second-most-sought-after fresh-water species in the Savannah River. However, because it is not often caught, it does not rank highly in annual catch statistics. This species is impinged rarely at SRP, comprising about 0.3 percent of the total fish collected (i.e., 2 individuals from a total of 684). The projection of annual losses under present operating conditions is 14 fish. An additional 6 largemouth bass would be lost annually as a result of L-Reactor operations.~~

4.1.1.3 Ground-water usage

During the renovation of L-Reactor, two new wells were drilled. In 1981 and 1982, they produced about 0.28 cubic meter per minute from the Tuscaloosa Formation. They produced about 0.94 cubic meter per minute in 1983. This withdrawal rate is not expected to increase when L-Reactor operation is resumed (Du Pont, 1981b).



Source: ECS (1983 a,b)

Figure 4-1. Average number of fish impinged daily at 1G, 3G, and 5G intakes compared to Savannah River water level from March 1982 through August 1983.

Table 4-2. Estimated numbers of fish that would be lost annually due to impingement under average river flow conditions (based on data from September 1982-August 1983)

Species	Percentage of total number impinged	Estimated loss under present operating conditions	Loss due to L-Reactor operation (estimated)	Total loss with L-Reactor operational (estimated)
AY-6 Bream	20	2,633	1114	3,747
Crappie	3	436	184	620
Catfish	3	335	142	477
Largemouth bass	0	30	13	43
Other species	74	9,989	4226	14,215
All species	100	13,423	5679	19,102

When L-Reactor is operational, withdrawal of ground water from the Tuscaloosa Aquifer (excluding incremental pumping by its support facilities), is estimated to be 20.5 cubic meters per minute at the Savannah River Plant and about 56.5 cubic meters per minute from all users within about 32 kilometers of Savannah River Plant (Sections 3.4.2.5 and 5.1.1.4). Siple (1967) concluded that the Tuscaloosa aquifer could supply 37.8 cubic meters per minute at SRP with no adverse effects on the pumping capabilities in existing 1960 wells. Total SRP pumping from the Tuscaloosa in 1960 was about 18.9 cubic meters per minute.

AW-1 Drawdown calculations for the Tuscaloosa Aquifer suggest that water levels at the Plant boundary opposite A- and M-Areas would rise in relation to the levels measured in 1982 (Georgia Power Company, 1982; Du Pont, 1983h) if the SRP pumping rate decreases from 23.8 (1982) to 20.5 cubic meters per minute. These projected increases would be about 0.5 meter at Jackson and 0.4 meter at Talatha. Long-term cyclic water-level fluctuations near SRP often exceed 2 meters (see Figure F-12).

Computer modeling (Marine and Routt, 1975) indicates that the best estimate of the ground-water flux in the aquifer is about 110 cubic meters per minute throughout the Savannah River Plant and adjacent areas (Figures F-25 and F-31 show the study area). The current ground-water flux through the Tuscaloosa in the Marine-Routt study area is conservatively estimated to be 51 cubic meters per minute, which is the study's lower-bound estimate (see Section F.4.2). This compares with a withdrawal rate from the study area of 32.0 cubic meters per minute (20.5 for SRP + 11.5 for neighboring offsite users). Incremental and cumulative ground-water withdrawals are described in Sections 5.1.1.4 and 5.2.3, respectively.

Pumping tests were conducted on both new L-Area wells. One well had a drawdown of 8.2 meters and the other a drawdown of 12.2 meters when tested for

a short period of time at flow rates of 2.8 cubic meters per minute. From the average specific capacity of 0.27 cubic meter per minute per meter derived during the pumping tests, a short-time drawdown of 3.5 meters (including well entrance losses) at the center of the cone of depression is calculated for an L-Area well producing 0.94 cubic meter per minute.

The total drawdown 0.3 meter from the center of the cone of depression is 4.6 meters when the entrance losses are subtracted and the effects of pumping elsewhere on the Savannah River Plant are included. The upward head differential between the Tuscaloosa and Congaree Formations in L-Area is calculated to be about 3.7 meters (Figure 3-9). Thus, 0.3 meter from the center of the cone of depression, the head differential is about 0.9 meter downward. The upward head differential at the L-Area seepage basin, about 400 meters from the A-Area wells, is calculated to be 1.4 meters, principally in response to pumping in L-Area. Measurements of upward differentials over the last 10 years show a gradual decline of about 0.16 meter per year (Section 3.4.2.5). This rate of decline, if it continues, will further reduce the upward head differential beneath the L-Area seepage basin. However, because pumping rates at SRP are expected to remain less than the 1983 rate (see Table F-10) over the next 6 years (Sections 5.1.1.4 and 5.2.3), this trend is expected to be retarded. The hydrostratigraphic properties of the formations underlying the L-Area seepage basin [principally the green clay (see Section 4.1.2.2) and the pisolitic clay at the base of the McBean and Congaree Formations, and the thick upper clay layer of the Ellenton Formation (Table F-1)] will tend to protect the Tuscaloosa from contamination by the seepage of pollutants that enter the overlying shallow ground-water units. The upward head differential will provide additional protection.

As noted in Section 4.1.2.2, contaminants from the L-Reactor seepage basin that reach the water table are expected to follow a ground-water travel path to Steel Creek, where they will be discharged through seepage springs. Any contamination that might reach the Congaree or Tuscaloosa from L-Area would flow beneath the SRP to the Savannah River and would not affect offsite ground-water users; the following ground-water transient times have been estimated (Figures F-25 and F-26 for flow paths and Table F-1 for flow velocities):

AW-1

- Congaree Formation -- 76 years
[(12.2 x 10³ meters)/(160 meters per year) = 76 years]
- Tuscaloosa Formation -- 250 years
[(13.1 x 10³ meters)/(52.2 meters per year) = 250 years]

Pumping from the Tuscaloosa in L-Area will have no effect on the heads in the Congaree and overlying formations because this aquifer has a very poor hydraulic connection with them. The withdrawal of ground water from the Tuscaloosa in L-Area is not expected to affect either the quality of the water or the offsite water levels in the aquifer.

In conclusion, the withdrawal of ground water for L-Reactor would be about 0.94 cubic meter per minute. The ground-water withdrawal from the Tuscaloosa is projected to decrease when L-Reactor operation resumes (excluding incremental pumping in support of L-Reactor) compared to 1982 pumping; water levels are expected to rise as a new equilibrium piezometric surface is established at SRP and neighboring areas. At Jackson and Talatha, projected water levels would

AW-1

increase by 0.5 and 0.4 meter, respectively, if sitewide pumping decreases to 20.5 cubic meters per minute. However, pumping at L-Area would draw down the water in the Tuscaloosa locally, and thereby reduce the upward head difference between the Tuscaloosa and Congaree to about 1.4 meters beneath the L-Reactor seepage basin. The withdrawal of ground water from the Tuscaloosa would not affect water levels in overlying aquifers because of the thick Ellenton clay unit and the basal Congaree Clay. Important clay layers, principally the green clay, beneath the L-Reactor seepage basin would tend to protect the Congaree and Tuscaloosa Aquifers; any contaminants that might reach these aquifers are expected to flow beneath the SRP to the Savannah River in an estimated 76 to 250 years, respectively, and would not affect offsite ground-water users.

4.1.1.4 Thermal discharge

TC

The direct discharge of L-Reactor cooling water to Steel Creek, discussed here, is the reference case to which all mitigation measures (including the preferred alternative) are compared (see Section 4.4.2). The preferred alternative is discussed in Section 4.5 and Appendix L. Section 7.5 discusses the NPDES permit for L-Reactor.

TC

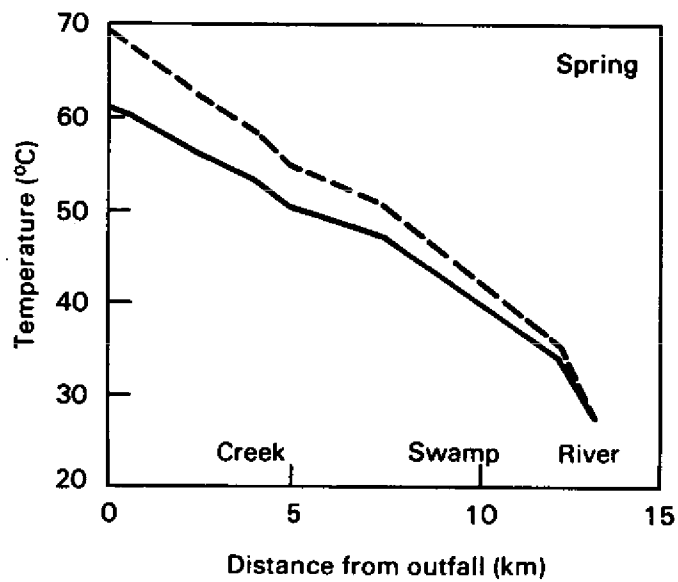
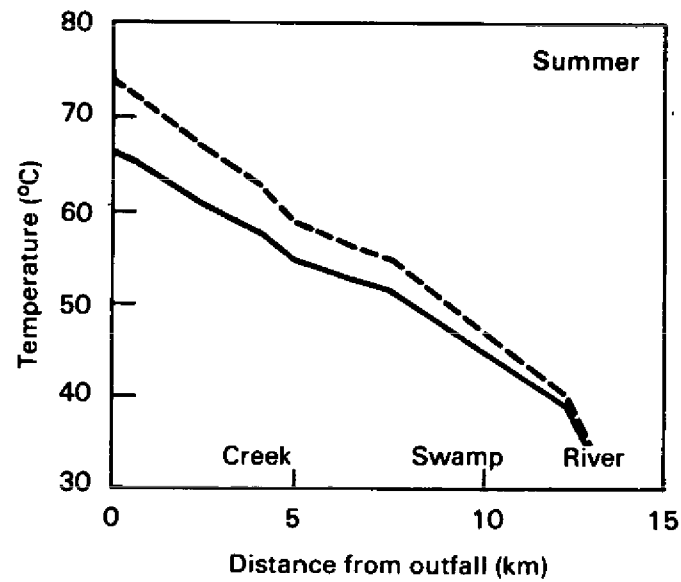
The L-Reactor cooling system would discharge thermal effluent directly into Steel Creek, one of five major creeks that drain the Savannah River Plant and flow into the Savannah River. The temperature of the effluent at the outfall canal would reach 73°C during extreme meteorological conditions. The effluent would flow at a rate of about 11 cubic meters per second (natural flow in the creek at Road B is about 0.17 cubic meter per second; see Section 3.4.1.2). Modeling (Du Pont, 1982b) of L-Reactor thermal effluents at two power levels (Figure 4-2) indicated that the thermal discharge would enter the swamp at temperatures between 40°C (spring) and 45°C (summer). Table 4-3 presents temperatures that could occur at selected points along Steel Creek under the most severe 5-day meteorological conditions (as determined from conditions between 1976 and 1980). If L-Reactor is operated under these severe conditions, the water temperature of Steel Creek above its delta would exceed 40°C; the temperature of the effluent when it reaches the Savannah River would be about 33°C (Table 4-3).

TC

TC

The thermal impact to wetlands would be expected to be similar to conditions that occurred when L-Reactor operated previously. During the past 15 years, through the process of natural succession, these wetlands have become reestablished. They are, however, structurally different from the closed canopy of mature cypress and tupelo gum that existed before SRP began operations (Sharitz, Irwin, and Christy, 1974). Elevated temperatures and water levels would eliminate between 420 and 580 acres of wetland vegetation within the Steel Creek corridor. Portions of these areas would revert to mudflats. Sediments would be transported downstream and deposited on the delta, contributing to its physical buildup and impacting vegetation.

With the reference case and other once-through alternatives, emergent wetland flora and submergent hydrophytes, which have revegetated the Steel Creek delta since 1968, would be eliminated and their substrates would also revert to mudflats after resumption of operations. Some herbaceous flora have also become established on exposed floodplain sediments and elevated stumps and logs of



Legend:

— 2000 MW
- - - 2400 MW

Source: Du Pont, 1982b.

Figure 4-2. Calculated temperature profiles for Steel Creek.

Table 4-3. Predicted seasonal water temperatures of Steel Creek as a result of L-Reactor operation (maximum load) and direct discharge

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
L-Reactor outfall	73 ^c	71	69	66
Road A	54	53	50	46
Road A-17	47	46	42	37
Swamp at delta	46	45	41	36
Mid-swamp	37	35	31	25
Mouth of creek at Savannah River	34	33	28	21

^aBased on the worst 5-day meteorological conditions (July 11-15, 1980) and the estimated operating power of the reactor. Five-day worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered representative of extreme temperatures for which the maintenance of a balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act of 1972.

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cThe secondary cooling-water discharge temperature during extreme summer meteorological conditions has been reduced to 73°C. This reduced temperature reflects reduced reactor operating power to compensate for increased temperatures in the cooling-water supply drawn from the Savannah River during the warmest summer months.

fallen trees. Most of the scrub-shrub and willow-dominated communities would be eliminated. Between 310 and 420 acres of the delta and swamp vegetation would be lost. Riverine vegetation near the mouth of Steel Creek consists primarily of bottomland hardwood forests; emergent and submergent macrophytes are sparse or absent. Temperatures as high as 11°C above ambient for short periods of time probably would not impact these flora. Temperatures of 11°C or higher above ambient are expected to occur about 10 times a year; each occurrence is expected to last about 2.5 days.

Flooding and siltation (from erosion of the stream bed and banks) associated with the thermal discharge at 11 cubic meters per second are expected to modify aquatic habitat in the Steel Creek floodplain and delta. The delta is expected to expand into the swamp at a maximum rate of about 3 acres per year. This growth rate was calculated using historic data (Ruby, Rinehart, and Reel, 1981) for the period when L-Reactor discharged 186-Basin and cooling-water effluents to Steel Creek. Wetland habitat is expected to be eliminated or modified at a rate of about 7 to 10 acres per year due to thermal discharge and its associated flooding, siltation (Smith et al., 1981), and fluctuating water

levels. If the L-Reactor resumed operation with direct discharge, about 420 acres of the wetlands in the Steel Creek corridor and about 310 acres in the swamp area, or about 730 acres total, would be initially affected (reference case). The 1000 acres of eliminated habitat represent a conservative estimate of the wetlands that would be affected over a number of years of reactor operation. [TC

Wildlife

Except for backwater pools or other cool-water refuges, the high water temperatures from the outfall to the delta (resulting from direct discharge, the reference case) would make the section of Steel Creek below L-Reactor uninhabitable for amphibian eggs and larvae. Adult life forms might survive along the stream margins or relocate to adjacent habits.

Reptiles are more dependent on aquatic habitat for food (i.e., insects, fish, amphibians) and shelter than for reproduction. The elevated water temperature and the elimination of prey organisms would eliminate the habitats of semiaquatic snakes and turtles upstream from the delta and would cause a marked decrease in species richness. Portions of the delta might provide marginal habitat for water snakes and turtles following L-Reactor restart.

The endangered American alligator inhabits all parts of Steel Creek from the L-Reactor outfall to the cypress-tupelo forest adjacent to the Steel Creek delta; it also uses areas lateral to Steel Creek, including Carolina bays, backwater lagoons, and beaver ponds. The number of alligators inhabiting the Steel Creek area ranges during the year between 23 and 35 individuals. Telemetry studies showed that males had larger home ranges than juveniles and females; males sometimes moved from the delta into the Savannah River swamp. The release of cooling water from L-Reactor would eliminate alligator habitat in Steel Creek from the reactor outfall to the Savannah River, except for backwater pools or other cool-water refuges, by increasing the water temperature above physiologically tolerable limits, eliminating principal food sources, and possibly inundating nests and shallow-water wintering habitats (Smith et al., 1981, 1982). Red sore, a bacterium-caused disease that affects fish and reptiles, could become more prevalent with thermal loading and could affect the American alligator. Conditions conducive to the reproduction of this bacterium, however, are very specific (i.e., water temperature, pH, etc.).

L-Reactor startup would take several days. Adult alligators should be able to avoid heated areas and emigrate to suitable nearby habitats. During winter, alligators might seek the warmer effluent waters until temperatures again rise above acceptable limits in late spring and summer. Juveniles also would be expected to avoid thermal effluents, but these smaller alligators would have more difficulty relocating to suitable habitats and would be exposed to greater predation. A startup in late spring and summer could destroy both nests and eggs. Winter startup could be fatal to torpid individuals that overwinter in shallow-water areas along the creek and in the delta. The DOE has initiated the consultation process with the U.S. Fish and Wildlife Service to determine the needed mitigation measures in the event of a winter or spring startup.

The Savannah River swamp and Steel Creek delta provide an important regional sanctuary and refuge for waterfowl. Over 400 wood ducks and nearly 1200 mallards have been observed roosting and feeding in the Steel Creek delta.

Seven other species of waterfowl also use this area. The Steel Creek delta also provides important foraging habitat for the wood stork, a large wading bird that is listed as an endangered species (USDOJ, 1984). A total of 102 birds was observed feeding in the Steel Creek delta in 1983. No wood stork nests occur on the SRP site. (DOE has initiated a consultation process with the U.S. Fish and Wildlife Service on the wood stork.) Thermal discharge would eliminate feeding and roosting habitat due to vegetative mortality and would adversely affect food sources such as fish because water temperatures would preclude their presence.

Semiaquatic mammals that would be affected by the thermal effluent include the beaver, river otter, mink, and muskrat. Adults should not experience mortality due to increased flow and temperature, but flooding during the breeding season could adversely affect the young. Except for the muskrat, these species are common throughout the Savannah River Plant.

Aquatic biota

The direct discharge of cooling-water effluent to Steel Creek (reference case) would eliminate most of the biota of the main channel from the L-Reactor outfall downstream to the delta. Populations of thermotolerant and thermophilic algae, such as blue-greens, would be expected to increase (Gibbons and Sharitz, 1974). These organisms thrive in areas where species more sensitive to elevated temperatures cannot compete. According to information on the SRP thermal streams (Four Mile Creek and Pen Branch), few higher organisms are likely to survive in the main-stream channel of Steel Creek. As the effluent moves away from the L-Reactor outfall, the temperature would decline and more organisms would occur, beginning with the most thermally tolerant (Du Pont, 1982b).

During thermal discharge, Steel Creek would not be suitable for fish of recreational or commercial importance; fish presently in Steel Creek would move to avoid heated effluents. In addition, the warmer waters of Steel Creek might prevent access to the floodplain swamp by fish from the river. Temperature tolerance data indicate that most, if not all, spawning activity could be eliminated by the thermal effluent; however, other similar spawning habitat is available in thermally unaffected areas on the Savannah River Plant and along the Savannah River. The most common fish remaining in the Steel Creek area probably would be the mosquitofish, although a few centrarchids might occur in backwater areas and tributary streams such as Meyers Branch (Cherry et al., 1976; Falke and Smith, 1974; Ferens and Murphy, 1974; McFarlane, 1976; McFarlane et al., 1978).

Although 2280 acres of the wetlands along Steel Creek above L-Area and along Meyers Branch above its confluence with Steel Creek would not receive direct thermal discharges, access to these areas by fish from the Savannah River will be restricted. The entrance to Boggy Gut Creek, an offsite tributary immediately downriver of Steel Creek, could be blocked by the thermal plume at times and fish access would be limited. Wetland areas of Boggy Gut total about 230 acres.

Thermal discharge to the Savannah River

Existing thermal discharges from the Savannah River Plant to the Savannah River include those from K-Reactor, which discharges to Steel Creek via Pen Branch, and C-Reactor and the D-Area powerhouse, which discharge to the Savannah

River via Four Mile Creek and Beaver Dam Creek, respectively. With the reference case, the resumption of L-Reactor operations would increase the thermal discharge to Steel Creek below its confluence with Pen Branch and increase the size of the thermal plume in the Savannah River.

Thermal plume. Since 1968 (K-Reactor operating and L-Reactor on standby), the discharge to the Savannah River from Steel Creek has been about 15.6 cubic meters per second at temperatures typically less than 5.6°C above ambient river temperature (Du Pont, 1982b). Judging from previous operating experience, the discharge with both K- and L-Reactors operating should increase to about 27.4 cubic meters per second; during the warmer months, the creek-to-river delta-T should average about 7.2°C.

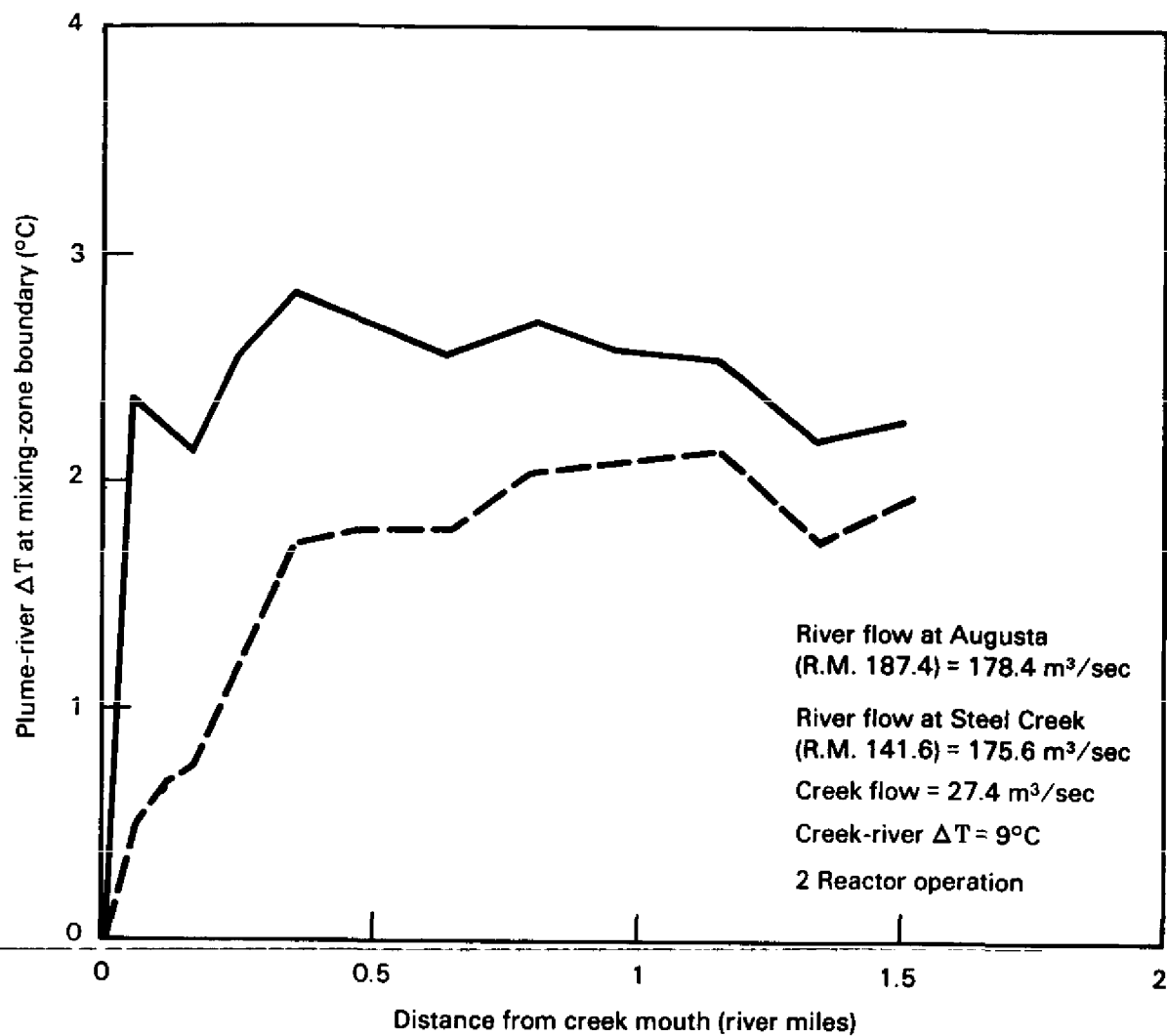
The thermal plume from Steel Creek would remain on the South Carolina side of the Savannah River until it becomes completely mixed with the river water, typically about 1.5 river miles (2.4 kilometers) downstream from the mouth of the Steel Creek (Du Pont, 1983b). Thus, a zone of passage for anadromous fish would exist in the river.

Computer simulations were used to predict the temperature in the Steel Creek thermal plume and at the point of entry into the Savannah River to the point of complete mixing of the plume with river water, about 1.5 river miles downstream from the mouth of the Steel Creek (Du Pont, 1983b). Figure 4-3 shows the results of this modeling for a river flow of 175.6 cubic meters per second at the mouth of Steel Creek that, with two reactors operating, corresponds to a flow of 178.4 cubic meters per second at Augusta (River Mile 187.4). A flow of at least 178.4 cubic meters per second is maintained 80 percent of the time at Augusta by the Army Corps of Engineers (see Section 3.4.1). Under the conditions shown in Figure 4-3, a creek-to-river delta-T greater than 9°C would be required to exceed a 2.8°C temperature difference across a mixing zone boundary in the river defined by 25 percent of the cross-sectional area of the river (see the upper, solid curve). The lower, dashed curve represents the temperature difference along a 33-percent surface-area mixing zone boundary.

Figure 4-4 is a compilation of the modeling results discussed above. The upper (solid) curve represents the calculated creek-to-river delta-T for corresponding river flows and only L-Reactor discharging to Steel Creek. Similarly, the lower (dashed) curve represents the case when the thermal effluent from both K- and L-Reactors is discharged through the mouth of Steel Creek.

The temperature increase of the Savannah River would depend on several factors: the time of the year, flow rates of the river, and SRP operating conditions. Table 4-4 lists the projected increases in water temperature from L-Reactor during August as a function of flow with three reactors discharging to the river.

Computer simulations also show that the mouth of Boggy Gut Branch would be affected by the L-Reactor thermal plume. These effects for the spawning months of February through June are shown in Figure 4-5; the computed temperature at the mouth of Boggy Gut Branch is plotted for the case of both K- and L-Reactors discharging through the mouth of Steel Creek and a river flow of 320 cubic meters per second. This river flow, which is 82 percent of the average flow during the 5-month spawning season (Figure 3-6), was chosen to reflect lower



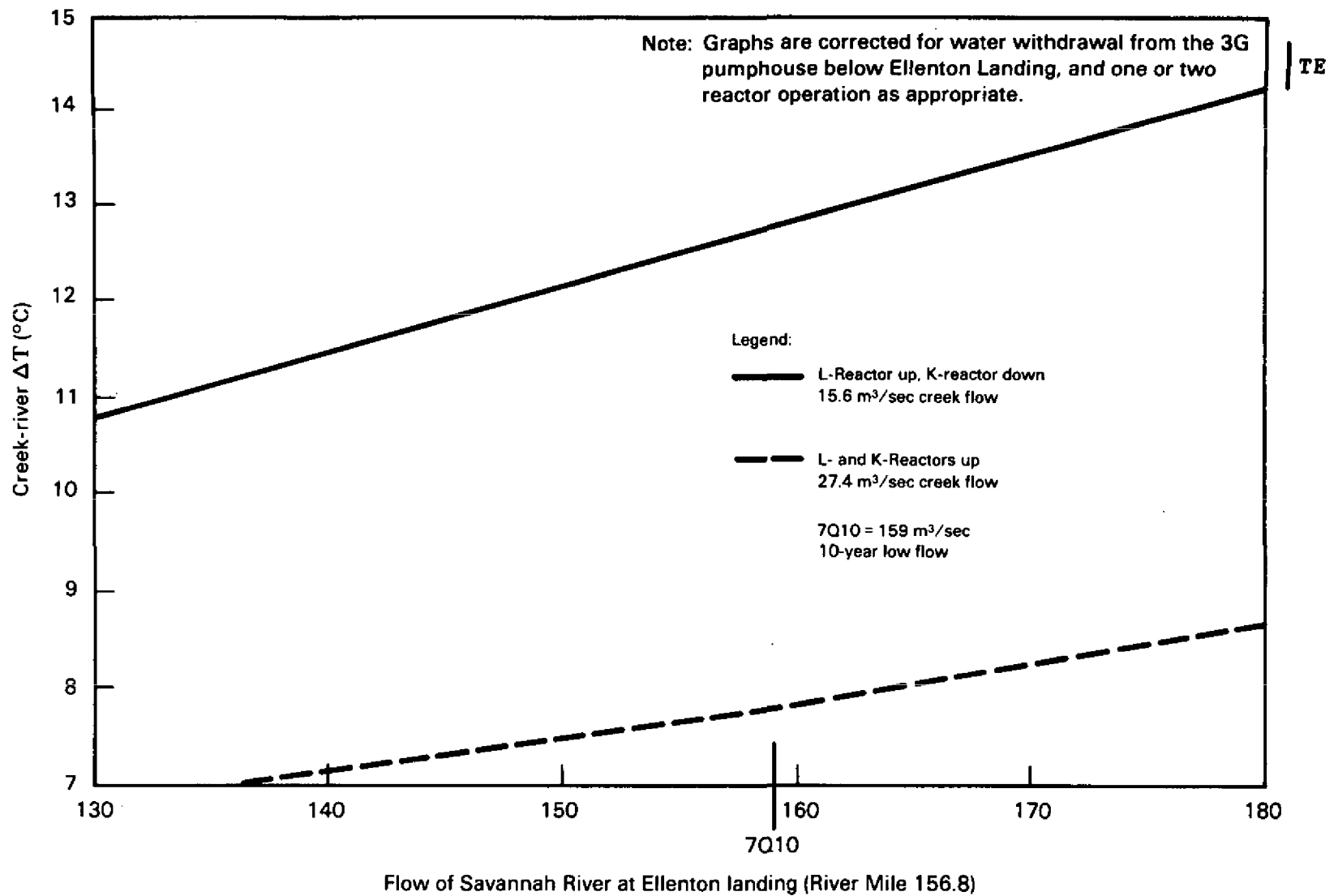
Legend:

— 25% cross-sectional area

- - 33% surface area

Adapted from Du Pont (1982b).

Figure 4-3. Temperature difference across mixing-zone boundary with distance down Savannah River below the mouth of Steel Creek (K- and L-Reactor operating).



Adapted from Du Pont (1982b).

Figure 4-4. Calculated creek-to-river delta-T (°C) to maintain a plume-to-river delta-T of no more than 2.8°C at a mixing-zone boundary defined by a 25-percent cross-sectional area and 33 percent of the surface area of the Savannah River.

Table 4-4. Projected L-Reactor contribution to the mixed river temperature increase during August^a

Savannah River flow at Ellenton Landing (m ³ /sec)	L-Reactor contribution to river temperature increase (°C)	Description of flow at Ellenton Landing
159.0	0.70	7-day, 10-year low flow
179.4	0.67	Mean for annual 7-day low flows, 1964-1983
295.0	0.45	Long-term average flow

^aAdapted from Du Pont (1982b).

flows that might occur as the result of the filling of Russell Dam (Section 3.4.1) and lower flows during periods of drought. Two temperature curves are plotted for the mouth of Boggy Gut Branch, one for a Steel Creek-to-river delta-T of 7.2°C (average) and another for a delta-T of 11.1°C (24 events per year with a 2.5-day duration on the average). Figure 4-5 also shows the monthly average maximum river temperature measured daily at Ellenton Landing.

Ecological impacts. Direct discharge would produce a thermal impact on the Savannah River only near the mouth of Steel Creek. Downriver from the confluence of Steel Creek with the river, no adverse impacts to reptiles, birds, or mammals that inhabit the river's riparian habitats are expected.

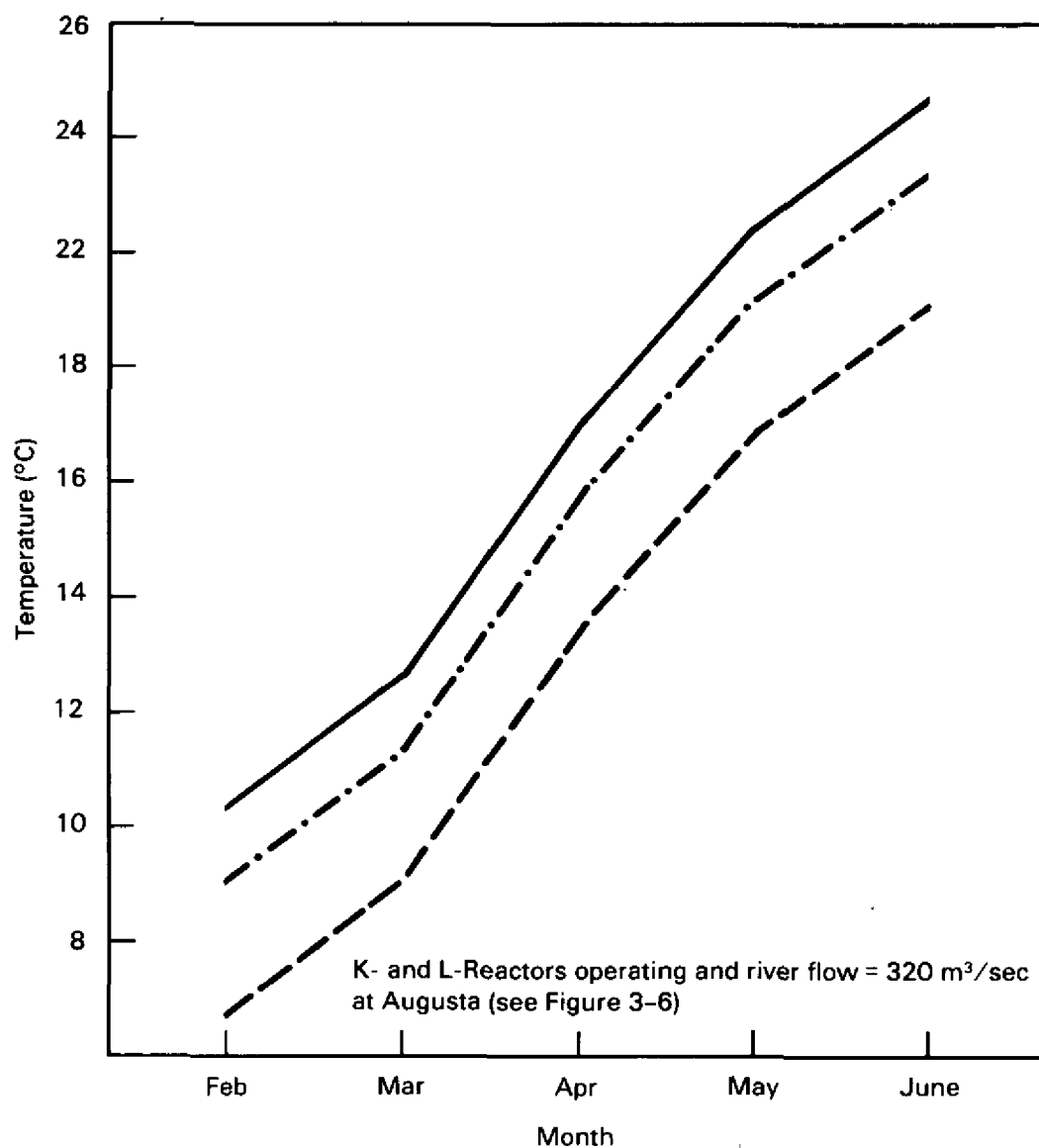
The temperatures near the mouth of Steel Creek could be high enough to exclude the creek and its floodplain as potential spawning areas for riverine and anadromous fish such as the blueback herring during the spawning season. However, temperature measurements in the river (Du Pont, 1982b) and thermal modeling indicate that the thermal plume would remain close enough to the South Carolina shore to permit a zone of passage for migrating fish such as American shad, blueback herring, striped bass, and Atlantic and shortnose sturgeon (Du Pont, 1982b).

Studies were conducted by the Academy of Natural Sciences of Philadelphia (ANSP, 1953, 1957, 1961, 1967, 1970, 1977) to monitor the effects of SRP operations on the general health of the Savannah River. ANSP studies (Matthews, 1982) indicate that no major changes in the presence of species have occurred from past Savannah River operations at their stations or are expected to occur from the addition of heat and cooling water from L-Reactor.

4.1.1.5 Wastewater discharges

Liquid effluent discharges to Steel Creek

Liquid effluent from L-Area would have chemical compositions that are similar to those from other SRP reactor areas. The L-Area effluent streams and their approximate annual flow rates are listed in Table 4-5.



Temperatures at Boggy Gut Branch

- ΔT at Steel Creek = 11.1°
- · - ΔT at Steel Creek = 7.2°
- - - Monthly average maximum daily river temperature at Ellenton Landing (1960-1969)

Figure 4-5. Temperatures at Boggy Gut Branch during the spawning season.

Table 4-5. Sources of effluent streams to Steel Creek from L-Area^a

Effluent stream sources	Approximate annual flow rate (m ³)
Cooling water, process water, cooling reservoir, sanitary wastewater	3.4 x 10 ⁸
Heating/cooling, offices	1.4 x 10 ⁴
Water treatment plant	2.6 x 10 ⁵
Cooling water for engine building	1.6 x 10 ⁶

^aAdapted from Du Pont (1982b).

With the reference case, some of the chemicals discharged through these outfalls to Steel Creek would originate from the Savannah River water pumped through the reactor secondary cooling system. Table 4-6 lists estimated L-Area liquid effluent chemical loads and compares them with the corresponding water quality or drinking-water standard and with concentrations measured in Steel Creek and in the Savannah River above and below the Savannah River Plant. Available measurements from the Savannah River (Table 4-6; Marter, 1970; Matthews, 1982) indicate little variation in measured quantities between upstream and downstream locations from present SRP operations; L-Reactor operation would not be expected to alter this situation significantly. Because of the high cooling-water flow rates to Steel Creek, most chemical contaminants would be expected to be transported through the swamp into the Savannah River, although flocculated suspended sediments would be expected to settle and accumulate in the swamp. No significant impact on swamp-water quality would be expected.

Sanitary discharges

Sanitary wastewater would be chlorinated at a packaged treatment plant and discharged through the L-Reactor area wastewater sewer to Steel Creek. The sanitary wastewater-treatment plant is designed for a maximum flow of 132 cubic meters per day. The treatment-plant size was selected to be adequate for the expected operating work force. The discharge would meet NPDES permit (Du Pont, 1981a) requirements and would have no major impact on Steel Creek (Du Pont, 1982b). Sewage sludge would be transported to an existing basin near the Central Shops. Samples of sludge from similar treatment facilities indicate that it is not hazardous (Du Pont, 1982b).

Cooling-water reservoir (186-Basin)

The 95-million-liter cooling-water processing basin (186-Basin) is cleaned annually during periods of reactor shutdown to remove accumulated solids. About 110 metric tons of the 5530 metric tons of suspended solids that would enter the 186-Basin annually are expected to be deposited in the basin. This sediment would be flushed to Steel Creek over a period of several days. During flushing, the suspended solids concentrations in the effluent would be about 60 to 160 parts per million. This operation, which requires a variance from NPDES permit

Table 4-6. Comparison of L-Area effluents with water-quality standards and Savannah River and Steel Creek measurements

Constituent ^a	Water quality/ drinking water standard ^b	Savannah River (3.6 km above SRP) 1982 avg ^c	Projected L-Area effluent ^d	Steel Creek (Road A) 1982 avg ^c	Savannah River (16 km below SRP) 1982 avg ^c
pH (no units)	6.5-8.5 (S)	6.2-7.0	6.4-7.1	6.4-7.8	6.4-7.1
Dissolved oxygen (DO)	>4 (WQS)	9.4	+ ^e	8.6	9.3
Total suspended solids (TSS)	<50 (WQS)	10	17.6	7.8	12
Total dissolved solids (TDS)	<500 (S)	67	+	55	67
Biological oxygen demand (BOD)	— ^f	1.9	5.1	+	1.9
Chemical oxygen demand (COD)	—	+	20.6	13	+
Ammonia (NH ₃)	—	0.2	0.84	0.02	0.1
Chloride (Cl)	<250 (S)	6.1	6.2	5.6	5.3
Sulfite/sulfate - S (SO ₃ /SO ₄)	<250 (S)	7.6	12.1	3.7	7.2
Nitrite/nitrate - N (NO ₂ /NO ₃)	<10 (P)	0.52	0.68	0.14	0.51
Total phosphate (PO ₄)	—	0.19	0.19	<0.03	0.18
Surfactants	<0.5 (S)	+	0.09	+	+
Oil and grease	—	+	6.4	+	+
Calcium (Ca)	—	3.8	+	4.9	3.7
Sodium (Na)	—	10	7.4	4.7	9.5
Fluoride (F)	1.4-2.4 (S)	+	+	+	+
Aluminum (Al)	—	1.3	1.4	<0.85	1.0
Iron (Fe)	<0.3 (S)	0.58	0.98	0.43	0.1
Magnesium (Mg)	—	+	0.12	+	+
Molybdenum (Mo)	—	+	0.01	+	+
Manganese (Mn)	<0.05 (S)	+	0.05	+	+
Cadmium (Cd)	<0.01 (P)	+	<0.003	+	+
Chromium (Cr)	<0.05 (P)	+	<0.04	+	+
Copper (Cu)	<1 (S)	+	<0.01	+	+

Table 4-6. Comparison of L-Area effluents with water-quality standards and Savannah River and Steel Creek measurements (continued)

Constituent ^a	Water quality/ drinking water standard ^b	Savannah River (3.6 km above SRP) 1982 avg ^c	Projected L-Area effluent ^d	Steel Creek (Road A) 1982 avg ^c	Savannah River (16 km below SRP) 1982 avg ^c
Lead (Pb)	<0.05 (P)	+	0.001	<0.05	+
Mercury (Hg)	<0.002 (P)	+	2.9×10^{-4}	+	+
Nickel (Ni)	<0.13 (WQS)	+	<0.03	+	+
Selenium (Se)	<0.01 (P)	+	0.004	+	+
Silver (Ag)	<0.05 (P)	+	4×10^{-4}	+	+
Zinc (Zn)	<5 (S)	+	0.07	+	+
^{t,1} BHC	$<9.2 \times 10^{-6}$ (WQS)	+	2.2×10^{-7}	+	+
Cyanide (CN)	<0.02 (WQS)	+	<0.02	+	+
Benzenze	<0.007 (WQS)	+	<0.002	+	+
Chloroform	<0.002 (WQS)	+	<0.001	+	+
Bis (2 chloro- isopropyl) ether	<34.7 (WQS)	+	0.002	+	+
Heptachlor	$<2.8 \times 10^{-6}$ (WQS)	+	4.4×10^{-8}	+	+
Total phenol	<3.5 (WQS)	+	<0.002	+	+
Methylene chloride	--	+	<0.001	+	+
Pthalates	<15 (WQS)	+	<0.001	+	+
Tetrachloro- ethylene	<0.0002 (WQS)	+	1.3×10^{-5}	+	+
Trichloroethane	<18.4 (WQS)	+	<0.001	+	+
Toluene	<14.3 (WQS)	+	0.001	+	+

^aAll concentrations expressed as milligrams per liter unless otherwise noted. The L-Area effluent, which will be discharged at a rate of about 11 cubic meters per second, will be diluted on reaching the Savannah River, which has a 7-day, 10-year low flow of 159 cubic meters per second and an average flow of 295 cubic meters per second.

^b(P) = 40 CFR Part 141; (S) = 40 CFR Part 143; (WQS) = Water Quality Standards—Federal Register, Part V, Vol. 45, No. 231, 28 November 1980.

^cDu Pont (1983c).

^dDu Pont (1982b).

^e+ = No data.

^f-- = No standard.

limits, is a continuation of current practice. It has been performed many times at the other reactors with no evidence of detrimental impact. Most of the suspended solids released from the 186-Basin would settle in the streambed before reaching the swamp (Kiser, 1977; Geisy and Briesse, 1978; Du Pont, 1981a; Ruby et al., 1981). When L-Reactor discharges resume (about 11 cubic meters per second), the resuspension of some of this settled sediment could contribute a small amount of material to the delta, which is expected to grow at a rate of about 3 acres per year with direct discharge (reference case).

4.1.1.6 Atmospheric releases

Nonradiological pollutants emitted into the atmosphere as a direct result of the operation of L-Reactor would come primarily from the K-Area coal-fired steam plant and the diesel generators at the L-Area.

The steam demands for L-Reactor would require an additional 6400 metric tons of coal to be burned annually at the K-Area steam plant. Emissions of particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and volatile organic compounds from the steam plant would increase 15 percent, as illustrated in Table 4-7. This facility was constructed before 1975. No modifications are required; therefore, existing permits allow the production of additional power.

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Fourteen emergency diesel generators are located in L-Area; six would operate continuously. The estimated annual diesel fuel consumption rate is 940 cubic meters for all generators. The emissions from these generators are listed in Table 4-7.

The operation of the L-Reactor would not violate any ambient air quality standard.

4.1.1.7 Solid wastes

Solid nonradioactive wastes generated by the resumption of L-Reactor operation would consist of trash and sanitary waste sludge. Trash would be generated at a rate comparable to those experienced by other SRP reactors; it would be disposed of in the SRP sanitary landfill. This landfill will be expanded from about 0.04 to 0.13 square kilometer. This expansion, which will occur in any event, ensures an adequate capacity for SRP operation, including L-Reactor, for many years (Du Pont, 1982b). Ten wells monitor the effluent from the landfill to the ground water of the McBean Formation. Quarterly analyses of water from these wells have shown little impact on the McBean ground water.

Periodically, treated sludge would be pumped from the sanitary waste treatment plant sludge holding tank to a mobile tank and transported to the sludge pit near the Central Shops area. Approximately 48,000 liters (50 percent water) of the sludge from L-Area would be disposed of in the sludge pit annually. No impact is expected on the operation of the sludge pit.

Table 4-7. Air pollutant emissions from K-Area steam plant and from sources supporting L-Reactor operation

Pollutant	Annual emissions ^a K-Area steam plant (metric tons/yr)	Incremented annual emissions ^b projected 1984 to support additional steam to L-Reactor (metric tons/yr)	Annual emissions ^c diesel generators at L-Reactor area (metric tons/yr)
Particulate matter	187	28	4
Sulfur oxides	870	130	4
Nitrogen oxides	345	52	59
Carbon monoxides	46	7	
Volatile organic compounds	23	4	

^aBased on present coal consumptions of 46,400 metric tons per year.

^bBased on 6400 metric tons per year coal consumption.

^cBased on burning 940 cubic meters diesel per year.

4.1.1.8 Noise

During the normal operation of L-Reactor, external noise levels would primarily be those associated with the movement of motor vehicles; they would be well within acceptable levels in the area. At the nearest offsite residence, about 10 kilometers away, noise from normal operations would not be detectable. Inside buildings, operators exposed to noise from machinery and other operating equipment would wear protective equipment in accordance with SRP standards and regulations of the U.S. Occupational Safety and Health Administration.

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4.1.2 Radiological impacts of L-Reactor operation

The operation of L-Reactor would have radiological impacts similar to those of the currently operating SRP reactors. The net effect would be about a one-third increase in the release of radioactive materials to the environment, in the total occupational dose of SRP workers, and in the amount of radioactive waste to be disposed of in the high-level waste tanks and in the low-level waste burial ground. This section characterizes these radiological impacts due to the normal operation of L-Reactor only under the reference case (direct discharge of cooling water to Steel Creek). Radiological impacts due to SRP facilities that would support L-Reactor are addressed in Section 5.1.2. Appendix B describes dose calculation models and basic assumptions.

Figure 4-6 shows potential pathways for radiation exposures to man from radionuclides released from a nuclear facility. External doses result from exposure to airborne effluents, from swimming and other recreational activities, and from exposure to ground deposition of radionuclides. There are no known users of Savannah River water for irrigation downstream from SRP (Section 3.4.1.3); contaminants that might reach the ground water beneath SRP will not reach offsite sources that are used for irrigation (Section 5.1.1.2; Appendix F, Figures F-25 and F-26). Internal doses result from the inhalation of airborne effluents and the ingestion of food and water that contain radionuclides.

DA-17

4.1.2.1 Atmospheric releases of radioactivity

Radioactive materials would be released to the atmosphere during L-Reactor operation from three release points: (1) from the 61-meter stack, which would discharge most of the gaseous effluents generated in reactor-building operation, (2) at ground level from evaporation of water from the fuel and target disassembly basin, and (3) at ground level from evaporation of water from the L-Area seepage basin. The releases from the stack would consist of radionuclide gases that enter the reactor ventilation system from the evaporation of process water, from the pressurized reactor blanket gas system, and from the air space between the reactor and the thermal shield.

Tritium releases would increase as the tritium content of reactor process water builds up to equilibrium. Table 4-8 lists the expected first- and tenth-year (equilibrium) atmospheric releases from normal L-Reactor operation (Du Pont, 1982b). The values are based on annual releases from P-, K-, and C-Reactor operations for 1978, 1979, and 1980; however, the values for tritium

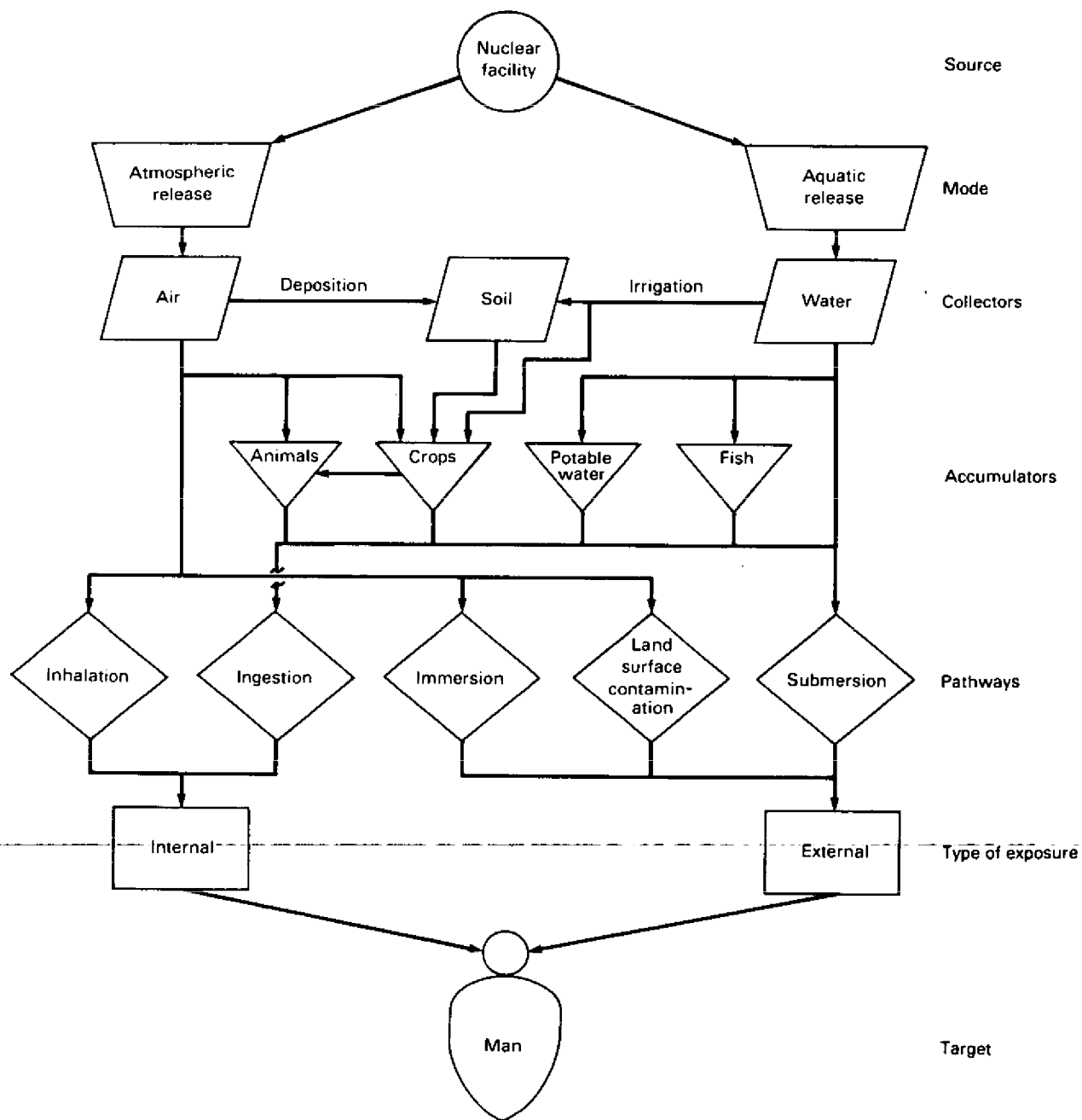


Figure 4-6. Assessment methodology used to calculate radiological impact on man.

Table 4-8. Expected annual atmospheric releases from L-Reactor operation^a (curies per year)

Radionuclide	1st-year operation	10th-year operation
H-3 ^b	5,490	54,900
C-14	12	12
Ar-41	19,500	19,500
Kr-85m	600	600
Kr-87	540	540
Kr-88	790	790
I-131	0.00414	0.00414
Xe-133	1,700	1,700
Xe-135	1,400	1,400
Unidentified beta-gamma ^c	0.0002	0.0002
Unidentified alpha ^d	0.000001	0.000001

^aThe expected annual average concentrations at the SRP site boundary would be well within the DOE concentration guides for uncontrolled areas (DOE, 1981b).

^bIncludes evaporative losses at ground level from the disassembly basin and the seepage basin.

^cAssumed to be strontium-90.

^dAssumed to be plutonium-239.

evaporation from the disassembly basin and for tritium from the seepage basin have been adjusted for more frequent target discharges expected at L-Reactor.

4.1.2.2 Wastewater discharges of radioactivity

During normal operations, radioactive materials would be discharged in liquid effluents from L-Reactor to Steel Creek as a result of small process-water leaks into the cooling water in the reactor heat exchangers, and by releases into the process sewer. Liquids (as much as 1890 cubic meters) would also be discharged about twice a year from the disassembly basin to the L-Reactor seepage basin (Figure 3-10). This purge of water would be necessary to keep the tritium concentration in the disassembly basin water below the level that ensures safe working conditions. The water in the disassembly basin would become contaminated when fuel and target assemblies are discharged from the reactor; some tritium and other radionuclides would be carried over in the process water adhering to the assemblies, and some as tritiated heavy water (DTO) contained as water of hydration in aluminum oxide on the assemblies. The disassembly basin water would be filtered, deionized, and monitored before it is discharged. The amount of tritium discharged in liquid effluents from L-Reactor would gradually

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increase with time as the tritium content of process water increases from neutron activation. After about 10 years of operation, the tritium content of process water would reach equilibrium (i.e., amount of new tritium produced equals amount lost through radioactive decay, leakage, and carryover and discharge operations) and remain relatively constant with continued reactor operation.

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The migration of the discharged liquid in a shallow aquifer from the seepage basin to the outcrop along Steel Creek would allow the tritium to partially decay before being discharged to the creek. Only local and minor changes in watertable elevations are expected. The green clay and important confining clays in underlying formations would prevent releases to the seepage basin from impacting the upward head differential between the Tuscaloosa and Congaree Formations. It would also be an important barrier to the migration of contaminants from the seepage basin to lower hydrostratigraphic units. In the Separations Areas, the green clay (about 2 meters thick) supports a head difference of about 24 meters between the McBean and Congaree Formations. Based on water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin [well 35-D (Figure F-34)], the green clay has effectively protected the Congaree ground water from contamination that enters the shallow ground-water system from the H-Area seepage basins (Marine, 1965). Water samples obtained in February 1984 from Well 35-D confirm the absence of tritium contamination in Congaree ground water. In the L-Area, the green clay is about 7 meters thick. Along the strike at the Par Pond pumphouse well (Figure F-13), the green clay also supports a large head difference. The water pumped from the Congaree Formation at the Par Pond pumphouse shows no evidence of tritium contamination, even though the tritium concentration in this lake was measured at 27,000 picocuries per liter. Water pumped from the Congaree by the pumphouse well exhibited tritium concentrations of 170 picocuries per liter or less, in comparison to concentrations of 260 ± 60 picocuries per liter in offsite well water (Ashley and Zeigler, 1981).

AW-1,
DA-8

These discharges to a seepage basin would cause contamination of the uppermost layer of the water-table aquifer (Barnwell Formation). Subsurface contaminant migration is controlled by the rate and direction of ground-water flow, the absorptive capabilities of the sediments, and hydrodynamic dispersion. The sediments of the Savannah River Plant exhibit greater horizontal than vertical hydraulic conductivities, enhancing lateral movement (Root, 1983). Analyses indicate that the filtered and deionized disassembly-basin wastewater, after its discharge to the L-Reactor seepage basin, would seep into the shallow ground water and flow laterally to seepage springs along Steel Creek. The upward head differential between the Tuscaloosa and Congaree Formations at L-Area is presently about 3.7 meters (Figure 3-9; Section 3.4.2.1), except near the production wells, where the differential becomes 0.9 meter downward at 0.3 meter from the centers of the cones of depression; current projections call for the continued presence of an upward differential for 10 or more years after L-Reactor operation resumes. This head differential and the clay layers beneath L-Area would tend to protect the Tuscaloosa Aquifer (see Section 4.1.1.3). The SRP has discharged contaminated wastewater to seepage basins in the central part of the Plant site since the mid-1950s. To date, no contamination of the Tuscaloosa Aquifer has occurred in this area (Ashley and Zeigler, 1981; Marine, 1965). Contaminants that might reach the Congaree or Tuscaloosa would be discharged to the Savannah River in about 76 or 250 years, respectively, as noted in Sections 4.1.1.3 and F.2.3.2, and in Du Pont (1983h).

Amounts of radioactive materials that reach the outcrop area on Steel Creek were calculated as a function of time, considering ground-water travel time from the seepage basin area to Steel Creek (4.4 years), radionuclide retardation by ion exchange, and radioactive decay (Du Pont, 1982b; also see Appendix B). However, based on a travel path of 490 meters, a gradient of 1.88 percent, and a ground-water velocity of 14.5 meters per year per percent gradient, a more realistic travel-time estimate is 18 years (Root, 1983; also see Table F-1).

Ashley, Zeigler, and Culp (1982) also considered the radioactive material released to the seepage basin during previous L-Reactor operations. Isotopes that are highly mobile (e.g., tritium, rubidium-106, and promethium-147) will already have left the area (in accordance with the ground-water travel time of 4.4 years and the fact that the previous radioactive releases to the seepage stopped in 1969). Other discharged isotopes (e.g., cobalt-60, strontium-90, and cesium-137), which are almost immobile, will result in negligible doses because they decay almost completely before they exit at the outcrop.

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Table 4-9 shows expected annual liquid releases from L-Reactor operation for the first year and after the tenth year of operation (Du Pont, 1982b). The direct releases to Steel Creek and to the seepage basin are based on average annual releases from P-, K-, and C-Reactors during 1978, 1979, and 1980, but have been adjusted upward for the more frequent assembly discharges expected from L-Reactor operation. As noted in the table, 30 percent of the tritium discharged to the seepage basin is expected to be released to the atmosphere by evaporation. The expected average annual concentrations of radionuclides at the Steel Creek mouth are calculated to be well within the DOE concentration guides for uncontrolled areas (DOE, 1981b).

4.1.2.3 Dose commitments from releases from L-Reactor operation

Maximum individual dose from atmospheric releases. The individual who would receive the highest dose from atmospheric releases from L-Reactor was assumed to reside continuously at the SRP boundary about 12 kilometers from the reactor. The selection of the location of maximum potential dose was based on considerations of distance to the plant boundary, releases to the atmosphere, and meteorological dispersion characteristics.

The maximum total-body dose to an individual (a child) was calculated to range from 0.062 to 0.29 millirem in the first and tenth year, respectively (Table 4-10). These doses are only 0.067 and 0.31 percent, respectively, of the average dose of 93 millirem (Du Pont, 1982b) received by an individual living near the SRP site from natural radiation. More detailed dose data by age groups, organs, and exposure pathways are given in Appendix B.

Population dose from atmospheric releases. The total-body dose to the population of 852,000 (projected for year 2000) who would be living within 80 kilometers of the Savannah River Plant was calculated to range from 3.0 to 13.5 person-rem in the first and tenth year, respectively. More detailed dose data by age groups, organs, and exposure pathways are given in Appendix B.

Table 4-9. Expected average annual liquid radioactive releases from L-Reactor operation
(curies per year)

Radionuclide	1st year of operation				10th year of operation			
	To Steel Creek	To seepage basin	To Steel Creek from ground water ^a	Total to Steel Creek	To Steel Creek	To seepage basin	To Steel Creek from ground water ^b	Total to Steel Creek
H-3	3.6×10^2	1.1×10^3	--	3.6×10^2	3.6×10^3	1.1×10^4	6.0×10^3	9.6×10^3
P-32	--	1.2×10^{-3}	--	--	--	1.2×10^{-3}	--	--
S-35	--	9.5×10^{-3}	--	--	--	9.5×10^{-3}	2.9×10^{-8}	2.9×10^{-8}
Cr-51	--	1.8×10^{-1}	--	--	--	1.8×10^{-1}	--	--
Co-58,60	4.5×10^{-2}	3.7×10^{-4}	--	4.5×10^{-2}	4.5×10^{-2}	3.7×10^{-4}	2.1×10^{-4}	4.5×10^{-2}
Sr-89	--	7.0×10^{-5}	--	--	--	7.0×10^{-5}	--	--
Sr-90	1.6×10^{-4}	2.0×10^{-4}	--	1.6×10^{-4}	1.6×10^{-4}	2.0×10^{-4}	--	1.6×10^{-4}
Y-91	--	5.1×10^{-3}	--	--	--	5.1×10^{-3}	--	--
Zr-95	--	1.1×10^{-2}	--	--	--	1.1×10^{-2}	--	--
Ru-106	--	3.4×10^{-4}	--	--	--	3.4×10^{-4}	1.7×10^{-5}	1.7×10^{-5}
Sb-125	--	8.0×10^{-3}	--	--	--	8.0×10^{-3}	2.6×10^{-3}	2.6×10^{-3}
I-131	--	6.9×10^{-3}	--	--	--	6.9×10^{-3}	--	--
Cs-134	--	5.1×10^{-3}	--	--	--	5.1×10^{-3}	--	--
Cs-137	4.1×10^{-4}	4.4×10^{-2}	--	4.1×10^{-4}	4.1×10^{-4}	4.4×10^{-2}	--	4.1×10^{-4}
Ce-144	--	1.9×10^{-2}	--	--	--	1.9×10^{-2}	3.8×10^{-4}	3.8×10^{-4}
Pm-147	--	2.8×10^{-3}	--	--	--	2.8×10^{-3}	8.8×10^{-4}	8.8×10^{-4}
Unidentified beta-gamma ^d	1.1×10^{-1}	8.9×10^{-2}	--	1.1×10^{-1}	1.1×10^{-1}	8.9×10^{-2}	--	1.1×10^{-1}
Unidentified alpha ^e	2.0×10^{-5}	3.2×10^{-4}	--	2.0×10^{-5}	2.0×10^{-5}	3.2×10^{-4}	--	2.0×10^{-5}

^aOutcrop activities will not occur during the first 4 years of reactor operation; see Table 8-19 and Section F.2.10.

^bOutcrop activities after 15 years of L-Reactor operation. Due to long transport times in ground water, strontium-90, cesium-134, cesium-137, and plutonium-239 do not reach outcrop in the 15-year period.

^cThirty percent of this tritium is expected to evaporate.

^dAssumed to be strontium-90.

^eAssumed to be plutonium-239.

Table 4-10. Annual total-body dose to maximally exposed individual from atmospheric releases from L-Reactor (millirem per year)

Age group	1st year	10th year
Adult	0.052	0.21
Teen	0.054	0.23
Child	0.062	0.29
Infant	0.051	0.16

Maximum individual dose from liquid releases. The individual who would receive the highest dose from liquid effluents from L-Reactor operation is assumed to live near the Savannah River, downstream from the Savannah River Plant. This individual is assumed to use river water regularly for drinking, to consume fish from the river, and to receive external exposures from shoreline activities, swimming, and boating. This individual is also assumed to drink more water and eat more fish than an average person.

Total-body doses to the various age groups for the maximally exposed individual are shown in Table 4-11. Detailed dose tables by age groups, organs, and exposure pathways are presented in Appendix B. Generally, children would receive the highest dose, ranging from 0.0094 millirem in the first year to 0.11 millirem in the tenth year. More than 75 percent of these doses would be from drinking water; most of the remainder would be from fish consumption. The highest calculated organ dose would be about 0.26 millirem to the child's bone in both the first and tenth year of L-Reactor operation.

Table 4-11. Annual total-body dose to maximally exposed individual from liquid releases from L-Reactor (millirem per year)

Age group	1st year	10th year
Adult	0.0072	0.087
Teen	0.0056	0.062
Child	0.0094	0.11
Infant	0.0062	0.11

Population dose from liquid releases. Savannah River water is not used for drinking within 80 kilometers of Savannah River Plant; therefore the dose to the population in this area would come from eating fish and shellfish, from shoreline activities, and from swimming and boating.

The total-body dose to the population of 852,000 estimated to be living within 80 kilometers of the Savannah River Plant in the year 2000 was calculated to range from 0.0088 to 0.018 person-rem in the first and tenth year, respectively (Table 4-12). About 90 percent of this dose would be from the consumption of fish.

Table 4-12. Population total-body doses (100-year dose equivalents) from liquid releases from L-Reactor operation (person-rem per year)

Population group	1st year	10th year
80-km radius	0.0088	0.018
Beaufort-Jasper	0.29	5.0
Port Wentworth	0.46	8.2
Total	0.76	13.2

The Beaufort-Jasper and Port Wentworth population groups use the Savannah River as a source of potable water. While these groups are beyond the 80-kilometer radius of the Savannah River Plant (about 100 river miles downstream), the drinking-water doses have been calculated. The total-body dose delivered to these populations (about 317,000 people are expected to consume water from the Beaufort-Jackson and Port Wentworth water treatment plants by the year 2000) from drinking water was calculated to range from 0.75 to 13 person-rem in the first and tenth year of operation, respectively (Table 4-12). These doses would be about 0.0025 and 0.044 percent, respectively, of the exposure of about 29,500 person-rem to these populations received from natural radiation. Approximately 65 percent of the drinking-water dose would be from tritium in the first year of operation, increasing to greater than 95 percent in the tenth year. More detailed dose data by age groups, by organs, and by exposure pathways are given in Appendix B.

4.1.2.4 Cesium-137 and cobalt-60 redistribution dose commitment

As shown by Table 4-9, resumption of L-Reactor operation would add only small amounts of radionuclides to Steel Creek. However, the reactivation would transport a portion of the cesium-137 and cobalt-60 inventories that remain in the Steel Creek channel and floodplain.

The amount of cesium-137 and cobalt-60 transported from Steel Creek to the Savannah River and to the offsite Creek Plantation Swamp as the result of L-Reactor operation with the direct discharge of cooling water to Steel Creek (reference case) was calculated using empirical models based on monitoring in 1976 and 1982 of sediment and cesium-137/cobalt-60 transport in Steel Creek and on the historic flooding record for the swamp (Du Pont, 1982a, 1983a; Langley and Marter, 1973; Appendix D).

The total (both suspended solid and dissolved fraction) amount of radio-cesium estimated to be remobilized and transported from Steel Creek during the first year of resumed L-Reactor operation would be 4.4 ± 2.2 curies. In the second year, it is anticipated that this value would be reduced to 2.3 ± 1.8 curies. Thereafter, a 20-percent reduction in transport per year is assumed. Thus, after 10 years of resumed operation, approximately 14.4 curies of cesium-137 would have been transported to the Savannah River-swamp system (Du Pont, 1983a).

The 2.1-curie decrease from the first to the second year is based on the assumption that the cooling-water effluent would no longer desorb radiocesium from the creekbed and floodplain sediments in Steel Creek and that no more radiocesium would be contributed from vegetation. Based on recent studies (Du Pont, 1983a), the sediment-water transport estimate presented here is substantially less than initially estimated (Du Pont, 1982a); however, the original estimates of transport resulting from hot water desorption (1.7 ± 0.2 curies) and the loss of vegetation containing 0.4 ± 0.2 curie remain unchanged (see Section D.4).

The total amount of radiocobalt to be remobilized and transported from Steel Creek during the first year of resumed L-Reactor operation is conservatively estimated to be 0.25 ± 0.13 curie. This total would consist of a 0.16-curie-per-year fraction associated with sediment-water transport and a 0.09-curie-per-year fraction associated with desorptive transport. During the second year, as much as 0.14 ± 0.10 curie would be transported in association with the suspended sediments (0.16 curie per year $\times$ 0.876 decay factor = 0.14 curie per year; Hayes and Watts, 1983). Approximately 0.6 curie of cobalt-60 would be transported to the Savannah River-swamp system during the first 10 years of resumed L-Reactor operation (Du Pont, 1983a).

Tables 4-13 and 4-14 list the amounts of cesium-137 and cobalt-60, respectively, that would be transported and concentrations in water for the first, second, and tenth years after resumption of L-Reactor operation. Maximum concentrations of cesium-137 and cobalt-60 occurring 1.5 river miles below Steel Creek mouth (the point of complete mixing of Steel Creek and river water) is predicted to be $1/425$ and $1/3300$, respectively, of the Environmental Protection Agency (EPA) drinking-water standard. Concentrations in finished water from the Beaufort-Jasper and Cherokee Hill water treatment plants are predicted to be small fractions (at most $1/2200$ and $1/4160$ for cesium-137 and cobalt-60, respectively) of these drinking-water standards (Du Pont, 1983a).

The methodology used to calculate dose commitments for remobilized radio-cesium and cobalt-60 is discussed in Appendix B. The dose calculations were made with the assumption that all cesium-137 and cobalt-60 released from Steel Creek would reach the Savannah River and complete mixing in the river would occur within 2.4 kilometers of the mouth of Steel Creek at an annual average river flow rate of 295 cubic meters per second. The dose associated with the first year of L-Reactor operation was analyzed because releases would be highest in that year (4.4 curies of cesium-137 and 0.25 curie of cobalt-60) and would decrease continuously in subsequent years.

Table 4-13. Estimated cesium-137 remobilization from Steel Creek compared with current transport values (direct discharge)^a

Location	River Mile	Inventory transported (Ci/yr)				Concentration in water (pCi/l)			
		Current values	After restart			Current values	After restart		
			1st year	2nd year	10th year		1st year	2nd year	10th year
Steel Creek mouth	141.6	0.25	4.4	2.3	0.4	5.3	11.15	5.80	1.01
Savannah River at 1.5 river miles below Steel Creek	140.1	0.41 ^b	4.4	2.3	0.4	0.04 ^b	0.47	0.25	0.04
Hwy. 301 bridge	118.7	0.39 ^b	4.3	2.2	0.4	0.04 ^b	0.44	0.23	0.04
Hwy. 17 bridge	21.4	0.20 ^b	2.7	1.4	0.2	0.02 ^b	0.23	0.12	0.02
WATER-TREATMENT PLANTS									
Finished water									
Beaufort-Jasper	39.2	--	--	--	--	0.028	0.01	<0.01	<<0.01
Cherokee Hill	29.0	--	--	--	--	0.033	0.09	0.05	<0.01
EPA interim primary drinking-water standard	--	--	--	--	--	200	200	200	200

^aBased on mean transportation estimates made by Hayes (1983) and Hayes and Watts (1983) and data presented in Table D-16, and average flow rates in the Savannah River at locations indicated. Estimates of concentration and transport for the first, second, and tenth years represent only the contribution resulting from the remobilization of cesium-137 in Steel Creek by the resumed operation of L-Reactor. No alteration of existing water-treatment-plant systems was assumed.

^b1979-1982 average concentration measured at the Hwy. 301 bridge was 0.04 picocurie per liter; other values derived using appropriate flow rates and reduction factors.

Table 4-14. Estimated cobalt-60 remobilization from Steel Creek compared with current transport values (direct discharge)^a

Location	River Mile	Inventory transported (Ci/yr)				Concentration in water (pCi/l)			
		Current values	After restart			Current values	After restart		
			1st year	2nd year	10th year		1st year	2nd year	10th year
Steel Creek mouth	141.6	0.02 ^b	0.25	0.14	<0.01	0.3 ^b	0.63	0.35	0.02
Savannah River at 1.5 river miles below Steel Creek	140.1	0.02 ^b	0.25	0.14	<0.01	<<0.01 ^b	0.03	0.02	<<0.01
Hwy. 301 bridge	118.7	0.02 ^b	0.24	0.14	<0.01	<<0.01 ^b	0.03	0.02	<<0.01
Hwy. 17 bridge	21.4	0.01 ^b	0.15	0.09	<<0.01	<<0.01 ^b	0.02	<0.02	<<0.01
WATER-TREATMENT PLANTS									
Finished water									
Beaufort-Jasper	39.2	--	--	--	--	<0.003 ^c	0.02	<0.02	<<0.01
Cherokee Hill	29.0	--	--	--	--	<0.003 ^c	0.02	<0.02	<0.01
EPA interim primary drinking water standard	--	--	--	--	--	100	100	100	100

^aBased on mean transportation estimates made by Hayes (1983) and Hayes and Watts (1983) and average flow rates in the Savannah River at locations indicated. Estimates of concentration and transport for the first, second, and tenth years represent only the contribution resulting from the remobilization of cobalt-60 in Steel Creek by the resumed operation of L-Reactor. No credit is taken for removal of cobalt-60 by the waste-treatment process.

^bEstimated on the basis of 0.06 times the value for cesium-137.

^cBased on Kantelo and Milham (1983).

Maximum individual dose. The dose to the maximally exposed individual from redistribution of cesium-137 and cobalt-60 in the first year is shown in Table 4-15 by age groups. An adult would receive the maximum total-body dose of 3.5 millirem. Greater than 99 percent of this dose is from cesium-137. Fish consumption (34 kilograms per year) would account for 99 percent of the dose, and drinking water (730 liters per year) for 0.7 percent. Shoreline activities, swimming, and boating would account for the remainder of the dose. The maximum dose to an organ was calculated to be 5.3 millirem to the liver of a teenager and an adult. The total-body dose to an adult would decrease to 0.31 millirem in the tenth year.

Population dose. The total-body dose to the population within 80 kilometers of the Savannah River Plant from freshwater fish and saltwater shellfish consumption and from recreational activities on the river was calculated to be 9.0 person-rem in the first year (Table 4-16). About 99 percent of this dose would be from consumption of river fish and is almost entirely from cesium-137. Total-body dose to water consumers in Port Wentworth and Beaufort-Jasper was calculated to be 0.80 person-rem in the first year. About 95 percent of this dose would be accounted for by cesium-137. The dose calculations for these water consumers take into account the removal of a large fraction of the cesium-137 during the water-treatment process (Du Pont, 1983a). In the tenth year, the 80-kilometer-radius population dose would decrease to 0.80 person-rem and the combined Beaufort-Jasper and Port Wentworth water consumer dose would decrease to 0.067 person-rem. Additional tables providing detailed cesium-137 and cobalt-60 dose results by age groups, organs, and exposure pathways are given in Appendix B.

4.1.2.5 Summary of offsite dose commitments from L-Reactor operation

Table 4-17 summarizes the maximum individual and population dose commitments resulting from the resumption of L-Reactor operation. The numbers listed as totals for individual and population doses are conservative maximums; to receive these doses, the "composite" individual (or population) would have to occupy several locations simultaneously. In addition, the dose for radiocesium and cobalt-60 transport calculated for the first year would decrease continuously in subsequent years.

The composite maximum individual dose of 3.6 millirem would occur in the first year of L-Reactor operation and is about 26 times less than the average dose of 93 millirem (Du Pont, 1982a) received by an individual living near the SRP site from natural radiation. The composite dose in the tenth year would be 0.61 millirem. These doses are on the order of 1 percent or less of the DOE radiation protection guides (DOE Order 5480.1A, Chapter 11). The maximum population dose of 27.6 person-rem in the tenth year of L-Reactor operation would be less than 0.025 percent of the exposure of about 109,000 person-rem to the population living within 80 kilometers of the Savannah River Plant and the Beaufort-Jasper and Port Wentworth drinking-water population from natural radiation sources.

Table 4-15. First-year dose to the maximally exposed individual from redistribution of cesium-137 and cobalt-60 from Steel Creek (millirem per year)

Age group	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Adult	3.28×10^{-3}	3.88	5.30	3.48	2.83×10^{-3}	1.80	6.01×10^{-1}	1.08×10^{-1}
Teen	1.10×10^{-2}	4.00	5.31	1.86	9.42×10^{-3}	1.81	7.11×10^{-1}	8.66×10^{-2}
Child	2.29×10^{-3}	5.28	5.06	7.48×10^{-1}	1.99×10^{-3}	1.65	5.95×10^{-1}	3.45×10^{-2}
Infant	--	8.15×10^{-2}	9.55×10^{-2}	6.99×10^{-3}	--	2.56×10^{-2}	1.04×10^{-2}	5.26×10^{-4}

Table 4-16. First-year population dose from redistribution of cesium-137 and cobalt-60 from Steel Creek (person-rem per year)

Population group	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
80-km radius ^a	3.28×10^{-2}	1.38×10^1	1.74×10^1	9.04	2.84×10^{-2}	5.85	2.01	2.86×10^{-1}
Beaufort-Jasper ^b	--	4.45×10^{-1}	5.51×10^{-1}	2.94×10^{-1}	--	1.77×10^{-1}	6.11×10^{-2}	3.22×10^{-1}
Port Wentworth ^b	--	5.48×10^{-1}	7.53×10^{-1}	5.01×10^{-1}	--	2.55×10^{-1}	8.49×10^{-2}	9.59×10^{-2}
Total	3.28×10^{-2}	1.48×10^1	1.87×10^1	9.84	2.84×10^{-2}	6.28	2.16	7.04×10^{-1}

^aDose from consumption of fish and shellfish and recreational activities on the river.

^bDose from consumption of water from water-treatment plants.

Table 4-17. Summary of total-body dose commitments from the operation of L-Reactor

Source of exposure	1st-year dose	10th-year dose
MAXIMUM INDIVIDUAL ADULT DOSE (MILLIREM PER YEAR)		
Atmospheric releases	0.052	0.21
Liquid releases	0.0072	0.087
Radiocesium and cobalt transport	3.5	0.31
Total	3.6	0.61

Source of exposure	Dose within 80 kilometers of SRP		Port Wentworth and Beaufort-Jasper dose	
	1st year	10th year	1st year	10th year

REGIONAL POPULATION DOSE (PERSON-REM PER YEAR)

Atmospheric releases	3.0	13.5	--	--
Liquid releases	0.0088	0.018	0.75	13.2
Radiocesium and cobalt transport	9.0	0.80	0.80	0.067
Total	12.0	14.3	1.6	13.3

4.1.2.6 Health effects from L-Reactor operation

Radiation-induced health effects that could occur as a result of the resumption of L-Reactor operation (including atmospheric and liquid radioactive releases and radiocesium remobilization) were calculated using BEIR III risk estimators (Appendix B). The risk estimators used were 120 cancers and 257 genetic effects per 1,000,000 person-rem exposure. Multiplying the regional population doses (from Table 4-17) by these risk estimators projects the following effects: a maximum of 0.001 excess cancer fatality in the population within 80 kilometers of the Savannah River Plant from first-year L-Reactor operations, 0.002 excess cancer fatality from tenth-year operations, 0.003 genetic disorders from the first year of operation and 0.004 from the tenth year. Health effects that could occur in the downstream Savannah River water-consuming populations of Port Wentworth and Beaufort-Jasper include a maximum of 0.0004 excess cancer fatality from first-year operations, and 0.002 from tenth-year operations. The maximum risk of genetic disorders to these populations would be 0.0004 from first-year operations, and 0.003 from tenth-year operations.

4.1.2.7 Occupational dose

At the L-Reactor, occupational doses would be maintained as low as reasonably achievable. All personnel who work in or enter areas that have radiation-exposure potential receive personal monitoring devices. In addition, a comprehensive bioassay program is maintained for all employees who work in areas where there is a potential for a biological uptake of radioactivity.

Table 4-18 lists the total whole-body dose commitments to workers in the P-, K-, and C-Reactor areas for 1976 through 1980. Based on these data, the total average annual dose commitment to workers in the L-Area would be about 69 person-rem per year. The average work force in each reactor area is about 375 people; thus, the average annual individual dose to workers in the L-Area would be about 185 millirem per year.

Table 4-18. Total doses to workers
in P-, K-, and C-Areas

Year	Dose (person-rem)
1976	217.2
1977	231.2
1978	202.0
1979	184.4
1980	203.7
Average	207.7
Average per reactor-year	69.2

The dose commitment to workers during this recent period can be compared to the experience of the 1960-1968 period, during which the annual occupational dose commitment in the P-, K-, C-, and L-Areas averaged 200 person-rem per reactor year (Du Pont, 1982a). A continuing program is maintained to reduce the occupational dose further.

4.1.2.8 Solid radioactive waste

About 570 cubic meters of solid radioactive waste would be generated annually at L-Reactor. This waste would be packaged and transported to the SRP low-level waste burial ground. The burial ground is divided into sections to accommodate different levels of radioactivity. The waste is buried in earthen trenches that are about 6 meters deep and 6 meters wide. The exact location of the burial trenches is defined, and accurate records are kept of the contents of each trench. About 40 acres of the burial ground area are available for future use.

The volume of low-level waste added to the burial ground due to L-Reactor operation would occupy about 1 acre of the burial ground area for each 10 years

of operation. Offsite radiological effects of burial operations would be negligible.

4.2 ACCIDENTS

TC

This section describes the environmental impacts and risks of reactor accidents. It demonstrates that L-Reactor safety systems are designed and would be operated in such a manner that the risk to the public from accidental releases of radioactivity would be extremely small.

4.2.1 Reactor accidents

Radiological protection for the operating staff, the public, and the plant-site would be provided by extensive protective devices and systems at L-Reactor, all designed to ensure that accidents would be prevented, arrested, or accommodated safely. The requirements for these protection systems are based on a spectrum of postulated occurrences and accidents that the plant design must accommodate safely.

The occurrences considered range from relatively minor events such as routine equipment malfunctions to postulated accident situations with a potential for serious consequences. The predominant focus is on prevention of any accidents that could release radioactive material in excess of permissible limits.

Analyses of accidents postulated for the Savannah River Plant reactors are applicable to L-Reactor and used to:

- Ensure that the reactor would operate with acceptably low risk to the public and plant employees and to provide a basis for improved reactor systems that could lower these risks still further.
- Set reactor operating limits for each operating cycle, such that the reactor protective instrumentation and shutdown systems could terminate postulated transients without damaging reactor fuel, the reactor tank, or the radioactivity confinement system.
- Provide assurance that the radioactivity confinement system would operate reliably even in the most serious accidents.
- Specify the offsite emergency response system needed and how the system should be used.

Appendix G describes reactor-accident analyses in more detail.

4.2.1.1 Characteristics of reactor accidents

Accident types

The two types of reactor accidents of primary concern at SRP are release of fission products or other radionuclides from the irradiated reactor fuel and targets, and release of activation tritium from the reactor moderator. The release of fission products is most likely to occur due to fuel or target melting, which might result from either power surges or cooling-system failures. The release of activation tritium from the reactor heavy water is most likely to occur from spills or pipe breaks.

The principal hazard of these accidents is that the released radionuclides become airborne and are carried either to the plant worker onsite or to the offsite population. Radionuclides can also be dispersed by the reactor liquid effluent streams, but the hazards of such dispersal are several orders of magnitude lower than those of airborne dispersal in an accident situation.

If a reactor fuel assembly melts, the materials that can be released to the reactor-room air have been assumed to be:

- 100 percent of the noble gases, primarily krypton and xenon
- 100 percent of the tritium from the lithium-aluminum components
- 50 percent of the halogens, mainly iodine
- 1 percent of the other fuel materials as airborne particulates

TC

If the reactor heavy water (D_2O) is spilled it can evaporate, carrying off any tritium present as DTO vapor. As initially charged, the L-Reactor heavy water would contain trace amounts of tritium, but the tritium in the heavy water could eventually build up to an equilibrium inventory of 5 million curies over a period of 10 years or longer. (The inventory varies with the operating history of the reactor and is now about 3.5 to 3.7 million curies in operating SRP reactors. To be conservative, a higher value of 5 million curies is assumed for accident consequence calculations. This is about 20 percent higher than the highest value ever observed in SRP reactors.) In the event of a spill of the full moderator inventory, about 3 percent of the tritium is assumed to evaporate during the 2-hour period after the spill and then to be released from the stack and dispersed during that period.

TC

The SRP reactors, including L, are fitted with a confinement system to remove a large fraction of the radioactivity that might be released to the reactor room. In this confinement system, the reactor room is kept at a negative pressure by use of exhaust fans. The exhaust air is passed through moisture separators and then through high-efficiency particulate air (HEPA) filters and carbon filters to remove more than 99 percent of the particulates and the iodine. The noble gases are not removed by the filters. Airborne tritium is also assumed to be fully released. After filtration, the exhaust air is released through a 61-meter-high stack.

Fission products

Table 4-19 lists the radioactive fission product content for a fully irradiated SRP fuel assembly, the half lives of these fission products, the amounts

Table 4-19. Activity of radionuclides (typical) for one SRP fuel assembly at saturation

Group/radionuclide	Radioactive inventory (curies)	Half-life ^a	Percentage of inventory released by melting	Percentage of inventory passing through confinement
NOBLE GASES				
Krypton-85	5.702×10^2	10.7y	100	100
Krypton-85m	6.734×10^4	4.48h	100	100
Krypton-87	1.283×10^5	1.27h	100	100
Krypton-88	1.809×10^5	2.86h	100	100
Xenon-133	3.516×10^5	5.25d	100	100
Xenon-135	2.317×10^4	9.10h	100	100
IODINES				
Iodine-131	1.495×10^5	8.04d	50	0.6
Iodine-132	2.237×10^5	2.28h	50	0.6
Iodine-133	3.547×10^5	20.9h	50	0.6
Iodine-134	3.995×10^5	52.5m	50	0.6
Iodine-135	3.303×10^5	6.61h	50	0.6
ALKALI METALS				
Rubidium-86	5.072×10^1	18.8d	1	0.005
Cesium-134	3.813×10^3	2.06y	1	0.005
Cesium-136	1.234×10^3	13.0d	1	0.005
Cesium-137	4.633×10^3	30.1y	1	0.005
TELLURIUM-ANTIMONY				
Tellurium-127	6.977×10^3	9.35h	1	0.005
Tellurium-127m	4.040×10^2	109.d	1	0.005
Tellurium-129	3.210×10^4	1.16h	1	0.005
Tellurium-129m	8.705×10^3	33.5d	1	0.005
Tellurium-131m	1.930×10^4	1.25d	1	0.005
Tellurium-132	2.226×10^5	3.26d	1	0.005
Antimony-127	7.305×10^3	3.91d	1	0.005
Antimony-129	3.361×10^4	4.41h	1	0.005
ALKALINE EARTHS				
Strontium-89	2.385×10^5	50.6d	1	0.005
Strontium-90	6.980×10^2	28.8y	1	0.005
Strontium-91	3.050×10^5	9.48h	1	0.005
Barium-140	3.298×10^5	12.8d	1	0.005

Table 4-19. Activity of radionuclides (typical) for one SRP fuel assembly at saturation (continued)

Group/radionuclide	Radioactive inventory (curies)	Half-life ^a	Percentage of inventory released by melting	Percentage of inventory passing through confinement
COBALT AND NOBLE METALS				
Cobalt-58	none	70.8d	1	0.005
Cobalt-60	none	5.27y	1	0.005
Molybdenum-99	3.215×10^5	2.75d	1	0.005
Technetium-99m	2.774×10^5	6.01h	1	0.005
Ruthenium-103	1.638×10^5	39.4d	1	0.005
Ruthenium-105	5.879×10^4	4.44h	1	0.005
Ruthenium-106	3.800×10^3	1.00y	1	0.005
Rhodium-105	4.919×10^4	1.48d	1	0.005
RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS				
Yttrium-90	7.600×10^3	2.67d	1	0.005
Yttrium-91	2.858×10^5	58.5d	1	0.005
Zirconium-95	3.059×10^5	64.0d	1	0.005
Zirconium-97	3.107×10^5	16.9h	1	0.005
Niobium-95	2.743×10^5	35.0d	1	0.005
Lanthanum-140	3.359×10^5	40.3h	1	0.005
Cerium-141	3.028×10^5	32.6d	1	0.005
Cerium-143	3.111×10^5	33.0h	1	0.005
Cerium-144	1.202×10^5	284.d	1	0.005
Praseodymium-143	3.067×10^5	13.6d	1	0.005
Neodymium-147	1.163×10^5	11.0d	1	0.005
Neptunium-239	1.360×10^5	2.35d	1	0.005
Plutonium-238	0.300×10^2	87.7y	1	0.005
Plutonium-239	9.902×10^{-1}	2.4×10^4 y	1	0.005
Plutonium-240	9.033×10^{-1}	6.6×10^3 y	1	0.005
Plutonium-241	2.241×10^2	14.4y	1	0.005
Americium-241	none	432.y	1	0.005
Curium-242	none	163.d	1	0.005
Curium-244	none	18.ly	1	0.005

^aHalf-life units are indicated by m for minutes, h for hours, d for days or y for years.

that might become airborne in a meltdown, and the amounts that might be released through the confinement system.

As seen from the table, the fission products of primary concern from an SRP reactor accident would be noble gases and iodine. Most of these fission products have short half lives and are quite volatile.

Radiation exposures and health effects

The possible pathways by which accidental releases of airborne radioactivity from L-Reactor could result in radiation exposure to the offsite public and to the SRP workers include:

- Exposure to gamma radiation emitted by the radionuclides as they pass overhead (plume shine)
- Immersion in the plume of the release, resulting in inhalation of the radionuclides either with immediate exhalation or with retention in the body (depending on the radionuclide biochemistry)
- Immersion in the plume of the release, resulting in a skin contact dose due to tritium
- Exposure to gamma radiation emitted by radionuclides deposited on the ground from the air (ground shine)
- Ingestion of radionuclides in contaminated drinking water and food

Because of the volatile nature of the radionuclides that could be emitted in an L-Reactor accident and their associated short half lives (tritium has a comparatively long radioactive half life, but a short biological half life), the last two pathways would be less important than the first three in the accident analysis.

The radiation doses calculated from the spectrum of postulated accidents associated with L-Reactor (Section 4.2.1.4) are too low to produce any short-term clinical effects or fatalities. The concern, rather, is with possible latent health effects (i.e., cancers or genetic changes).

Extensive studies have been made in relating comparatively low levels of radiation exposure and health effects. The problem is difficult primarily because the effects are statistically so low as to be difficult to measure. For purposes of this analysis, radiation doses were calculated based on dose conversion factors from the International Council on Radiological Protection report ICRP-30.

4.2.1.2 Accident experience and prevention at SRP

Safe operation of the production reactors is implemented by (1) explicit definition of the safe limits of operation, (2) explicit written procedures for normal and abnormal operations, (3) multiple and diverse engineered safety systems and (4) in-depth technical support onsite. This system of operation was in

place when the first reactor was started at SRP and has been improved over the years when deficiencies were identified.

For long-term safety, an important function is the ability to spot weaknesses or adverse trends. Each deviation from approved operating procedures is recorded and promptly investigated by onsite technical personnel. If there appears to be a significant question of reactor safety, the reactor is shut down until it can be demonstrated that operation will be within the envelope of acceptable conditions required by the reactor operation and Technical Specifications and Technical Standards, which are established by DOE and the operating contractor, respectively.

Safety considerations override production considerations, and precautionary reactor shutdowns have occurred to investigate possible safety questions. The research at Savannah River Laboratory (SRL) ensures that the latest methods and equipment are evaluated for application to Savannah River Plant. Many important improvements have been made to SRP reactors; in the safety-related areas of thermal analysis, core physics, and monitoring and diagnosis, they equal the current state of the art. These improvements are summarized in Appendix J. Research at SRL includes human factors as well as plant equipment. The incident at Three Mile Island has been studied; lessons learned that are applicable to SRP reactors are being implemented (e.g., an improved reactor training program, the construction of a reactor simulator).

A comprehensive Safety Analysis is the basis for a defense-in-depth safety approach in which possible accident initiators are identified and eliminated to the maximum extent practical, multiple shutdown systems are provided to terminate, without damage, any accidents that do occur, and radioactivity confinement and other systems are installed to minimize the offsite effects of reactor damage if it does happen (Du Pont, 1983a). The emphasis in the Safety Analysis is on accident prevention and mitigation, but it also calculates the consequences of possible occurrences. TC

Provisions for independent safety reviews are required by DOE policy for each level of organization, including contractors, the field offices, and Headquarters. As part of this process, the Atomic Energy Commission's Advisory Committee on Reactor Safeguards served as an independent review body from 1960 to 1974. Numerous reviews by special committees and boards have been conducted periodically, including the Shon Committee in 1971, the Crawford Committee in 1980, and the Ditto Committee in 1981. The process also included the use of consultants. A formal safety consultant review policy was established after 1974. Currently, consultants are used on the Reactor Safety Advisory Committee initiated by the contractor in 1982. Significant steps to strengthen independent reviews were identified and taken as a result of post-TMI-2 reviews. These steps included organizational changes and staff to provide additional independent overview within DOE organizations.

SRP reactors have operated for more than 115 reactor-years with no accidental criticality or abnormal releases to the environment.

The most serious accidents that have occurred at SRP reactors are:

- A sizable moderator spill that occurred during the early stages of operation. At the time of the spill, the moderator contained very little tritium, so the radiation effects of the spill were negligible.
- In 1970, a special source rod melted while it was being held in the discharge machine. The confinement system worked as designed and 99.99 percent of the radioactivity released was trapped and recovered with negligible offsite exposure. This accident was the result of administrative error; appropriate procedural controls have been implemented to prevent a recurrence.

These and other reactor incidents are described in more detail in Appendix G and the Safety Analysis Report (Du Pont, 1983a).

4.2.1.3 Mitigation of accident consequences

Numerous reactor design features provide the ability to reduce the consequences of accidents. The most important of these include the following:

Reactor shutdown systems

Several redundant and diverse systems operate to shut down the reactor rapidly, if necessary.

L-Reactor would have the same defenses against reactivity transients that other SRP reactors have. These defenses would include flow and temperature sensors for each fuel assembly, which are monitored by two sets of redundant computers (control computers and safety computers). The control computer(s) would detect rapidly any reactivity transient that might begin and would cause the normal control-rod system to insert to terminate the transient safely--the first line of defense. If the normal control-rod system fails to terminate the transient, the safety computer(s) would activate the safety-rod drop system that would shut down the reactor within about 1 second--the second line of defense. If the safety rods do not shut down the reactor rapidly, the safety computer(s) would automatically activate the injection of liquid "poison" into the reactor moderator/coolant to accomplish the same safe shutdown--the third line of defense. The few reactivity transients that have occurred have been of a small magnitude, were controlled by the normal control-rod system, and did not require either backup system to operate (safety-rod drop or "poison" injection).

Emergency cooling system

An emergency cooling system (ECS) is provided to protect against the consequences of two postulated accidents: (1) loss of heavy-water coolant and (2) loss of heavy-water circulation.

Emergency cooling of the SRP reactors is accomplished by the addition of light water to the primary reactor cooling system. This water is enhanced in loss-of-coolant accidents by recirculation of the emergency light water by the primary heavy-water circulating pumps.

On activation, the ECS system provides an initial 75,000 liters of borated water for nuclear poisoning by directing all ECS water flow through a large pipe that contains the borated water. The poison solution is forced through the assembly coolant channels and into the moderator. By the time unpoisoned H₂O reaches the coolant channels, sufficient heavy water moderator is displaced with poisoned water to prevent any possible criticality.

Three primary sources and a secondary source of water for the emergency cooling system are provided and include the following:

1. A diesel-driven booster pump that supplies water from the 95-million-liter 186-L basin (primary).
2. A header with a diameter of 107 centimeters pressurized by five pumps drawing water from the 95-million-liter basin (primary).
3. Another header with a diameter of 107 centimeters pressurized by five additional pumps.
4. A line pressurized by the river station pumps. Because the water directly from the river can contain debris that could plug flow channels and orifices in the reactor components, this source is valved off from the ECS and would be used only if all other sources had failed (secondary).

Airborne activity confinement system

The L-Reactor is equipped with an airborne activity confinement system (see Figure G-1). In the event of an accident, an airborne fission product release could occur in the reactor room with the possibility of some release in the heat exchanger bay or pump room. The air from these areas would be exhausted through a set of confinement filters before release to the stack.

During normal operation, the process areas would be closed and maintained at a negative pressure with respect to atmosphere to ensure that all air from the process areas is exhausted through the activity confinement system. Three large centrifugal fans would exhaust the air from the process areas. Two of these fans normally would be online, but only one would be necessary to maintain the negative pressure. The fan motors could be powered by two independent sources of electricity:

- The normal building power, through at least two substations
- The diesel-generated emergency building power

In addition, each online fan has a backup motor; any two fans could be powered by the dedicated diesel generators.

Exhaust filters would remove moisture, particulates, and halogens. The filter banks are enclosed in five separate compartments; three to five of these compartments would be online during operation. Each compartment can be isolated

for maintenance and testing; each contains the following filter banks, in the order of air-flow treatment:

- Moisture separators, designed to remove about 99 percent of entrained water (spherical particles measuring 1 to 5 microns) to protect against significant impairment of the particulate filters
- Particulate filters, designed to retain more than 99 percent of all particulates with diameters of 0.3 micron or larger
- Activated carbon beds that use an impregnated carbon to retain halogen activity

As shown in Figures 4-7 and 4-8, L-Reactor is completely surrounded by a massive concrete structure, which in combination with the confinement system forms a barrier of high reliability against the possible release of radioactive material. The confinement system has the capacity to accommodate unexpected gas or energy releases. Hydrogen formed during an accident would be swept from the building by the high ventilation flow before explosive concentrations could be reached. Even with steam or hydrogen explosions for the worst hypothetical accident, the integrity of the structure and confinement system (including filters) would not be breached by rupture. Durant and Brown (1970) present a detailed analysis of a most severe hypothetical accident affecting the confinement system; this analysis specifically addresses the impact of hydrogen and steam explosions. Durant et al. (1966) documents confinement system tests that confirm the confinement system can withstand the severe accident conditions described above with a large margin of safety.

For all reactor accidents, the airborne activity confinement system is assumed to operate. The three exhaust fans described above would provide a high degree of assurance that at least one would remain in operation to maintain the process-area exhaust through the filter system. The probability that all three fans would fail is estimated to be 10^{-4} per year. Such a fan failure happening at the same time as one of the described accidents would be extremely unlikely.

Reactor room spray system

A system of nozzles is provided in the reactor room to spray cooling water on an irradiated assembly accidentally dropped during unloading operations. The spray pattern from these nozzles covers the area traversed by the discharge machine.

Site features

The site feature that would most effectively mitigate the consequences of an accident at L-Reactor is the 9-kilometer distance to the nearest SRP boundary. Although South Carolina Highway 125 is only 5 kilometers from L-Reactor, there are existing procedures for stopping traffic and clearing all personnel off the highway within a short time of any incident on the Savannah River Plant. (For more detail concerning site features, see Section 3.1.)

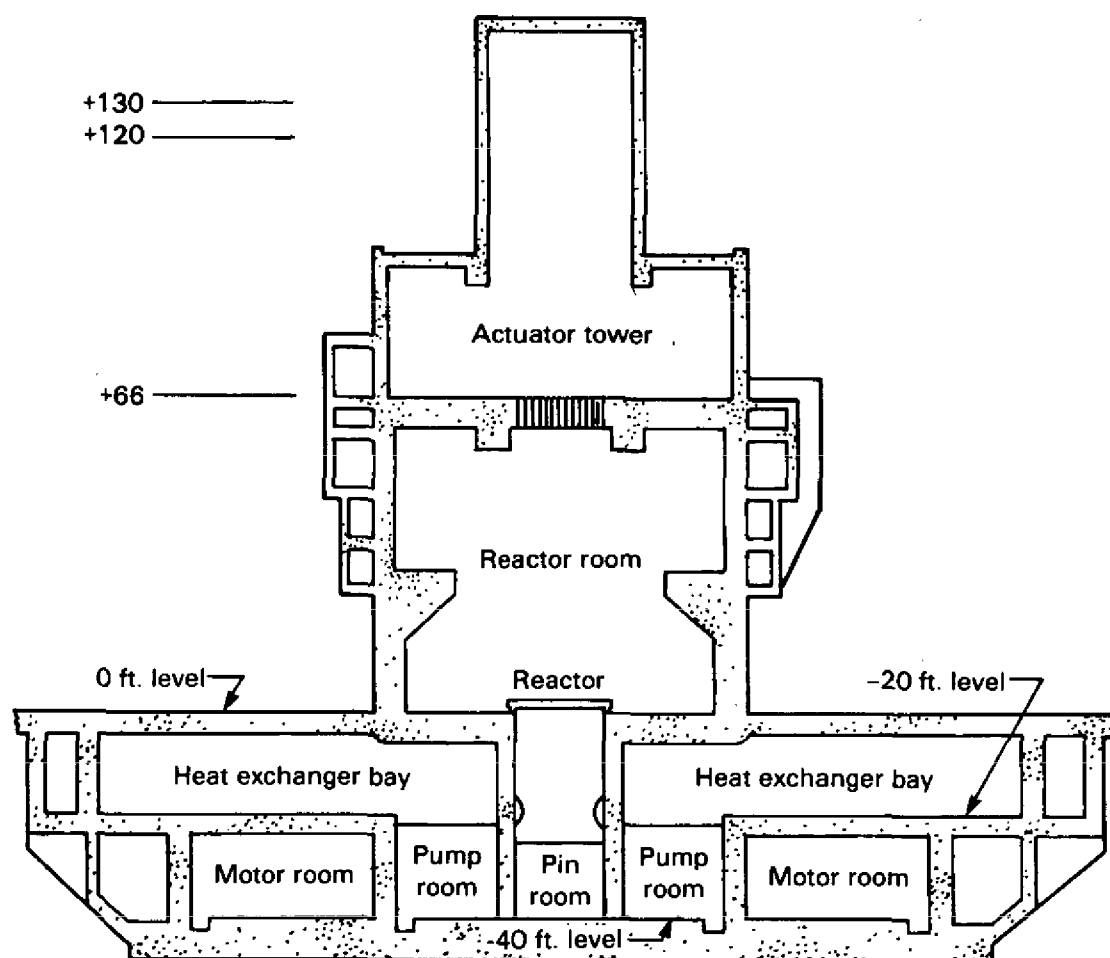


Figure 4-7. Schematic cross section of reactor process area.

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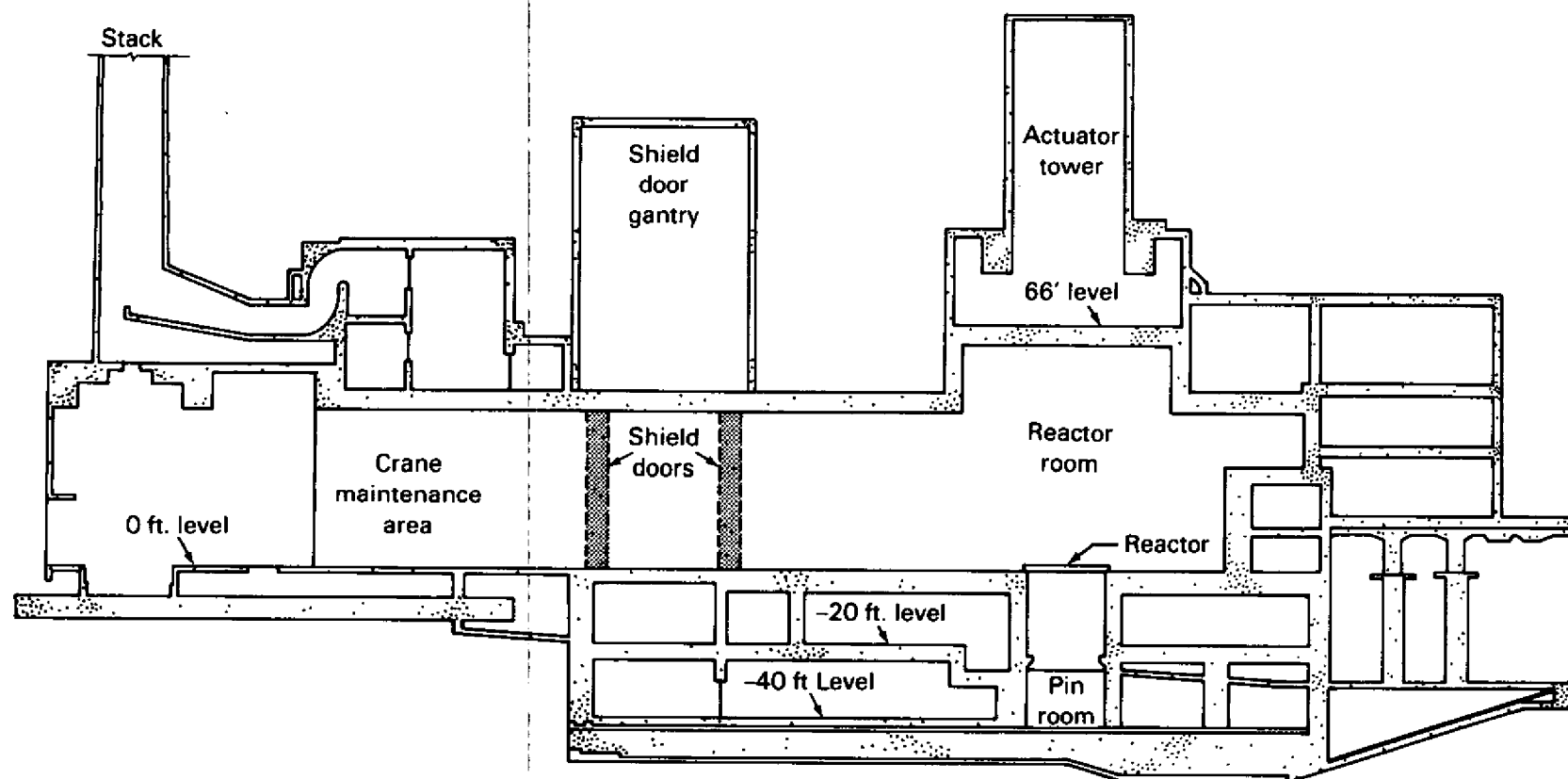


Figure 4-8. Schematic cross section of reactor.

Emergency planning

Onsite. The L-Reactor operating procedures include an Emergency Response Plan, which includes specific policies and procedures to minimize injuries and property damage caused by accidents, disasters, or deliberate damage in the reactor areas. The plan deals with sheltering or evacuation, nuclear incidents, civil defense readiness, missile or air attack, rescue plan, natural disasters and alerts, bomb threats, off-plant accidents, and forced entry or terrorist attack. (For more detail concerning Onsite Emergency Planning, see Appendix G.)

Offsite. DOE has various service agreements for assistance or special support with Fort Gordon and with Talmadge Hospital in Augusta, Georgia. DOE also has fire-fighting mutual aid agreements with the City of Aiken, South Carolina, and the South Carolina Forestry Commission. Memos of Understanding between DOE and the States of South Carolina and Georgia cover notification and emergency responsibility in the event of a potential or actual radiological emergency at the SRP. (For more detail concerning Offsite Emergency Planning, see Appendix H.) DOE continually reviews and updates its emergency planning procedures for consistency with applicable industrial and regulatory standards.

WIND system. The Weather Information and Display (WIND) System (Garrett et al., 1983) is an automated emergency response system for real-time predictions of the consequences of liquid and atmospheric releases from the Savannah River Plant. Site-specific features of the system include meteorological towers at each production area that are instrumented at the stack height, computer terminals at each production area that can be used to run emergency response codes remotely, codes that use empirical information on atmospheric diffusion and deposition gathered at the Savannah River Plant (Garrett, 1981; Carlson et al., 1982), and stream transport and diffusion codes that have been calibrated with dye tests in the SRP streams (Buckner et al., 1975). (For more detail concerning WIND, see Appendix G.)

4.2.1.4 Accident risk assessment

Accident description

Postulated events considered for safety evaluation of the L-Reactor are discussed in Appendix G and, more comprehensively, in the Safety Analysis Report (Du Pont, 1983a). Among these events are four postulated accidents that cover a spectrum of credible events with probabilities of greater than 10^{-6} per reactor-year that could release radioactive materials into the environment. Accidents with probabilities less than 10^{-6} per site-year are not considered credible.

Use of the probability of 10^{-6} per reactor-year as a threshold for credible reactor accidents has no absolute basis, but it is consistent with normal practice in the nuclear power industry. For example, this value can be derived from both an American National Standards Institute (ANSI) standard and the U.S. Nuclear Regulatory Commission Standard Review Plan. ANSI/ANS-212-1978, Appendix B, uses the value of 10^{-6} per site per year as a cutoff probability,

TC

TC below which combinations of events leading to accidents need not be considered for design purposes. The cutoff value does not include the probability of the consequences exceeding 10 CFR 100 dose guidelines, which is included in the NRC Standard Review Plan (NUREG-0800) acceptance criteria of 10^{-7} per year. The use of the 10^{-6} per site year value in the ANSI standard for accident probability is consistent with the NRC Standard Review Plan's value of 10^{-7} per site per year for accident plus consequence probability because the probability of the consequences exceeding 10 CFR 100 dose guidelines following an accident are conservatively estimated to be less than 10^{-1} . The SRP use of the 10^{-6} threshold is not for a so-called uncontrolled release, but for dividing "treated-as-credible" from "treated-as-noncredible" accidents. Even with estimates of accident probabilities beyond the 10^{-6} per reactor-year threshold, radioactive releases are limited by the performance of the reactor confinement system; they are not uncontrolled releases to the environment.

TC These four accidents are used for consequence and risk calculations. Other accidents or events are discussed in Appendix G, including the failure of an irradiated fuel or target component in the disassembly basin and various fuel-melt accidents. None of the accidents postulated would cause offsite doses that exceed either those adopted by DOE as safety limits for nuclear facilities (DOE Order 5480.1A) or those adopted by NRC as guidelines for siting for commercial power reactors (10 CFR 100). The four postulated accidents that cover the spectrum of credible events and risks are:

Moderator spill. Tritium in the moderator could become airborne and be partially released to the confinement system following ECS actuation or any loss-of-coolant accident. Tritium released into the confinement system is discharged from the stack, because the confinement system has no mechanism for tritium removal.

TC Five million curies of tritium are assumed to be present in the moderator of L-Reactor; this is the equilibrium value of tritium in the moderator and is 30 to 40 percent higher than present actual values for operating SRP reactors. The full moderator inventory of tritium is unlikely to evaporate and discharge to the atmosphere through the confinement system following any accident because ~~the moderator would flow first into the 225,000-liter tank and then to the~~ 1,900,000-liter tank of the liquid activity confinement system, unless the accident is a spill in the process room; in that case, most of the moderator would flow directly to the 1,900,000-liter tank. About 3 percent of the tritium is assumed to evaporate during the 2-hour period after the postulated accident and then to be released from the stack and dispersed during that period.

Discharge mishap. One irradiated fuel assembly could melt during a discharge operation under certain adverse (and improbable) conditions and release noble gases, iodine, and particulates. Fifty percent of the iodine and 100 percent of the noble gases available for release are assumed to escape the assembly and become airborne within the confinement system. More than 99 percent of that iodine reaching the carbon filter beds would be removed by the filter (a small fraction would desorb later and be released); 100 percent of the noble gases reaching the filters would pass through the filter. Half of the particulates released to the confinement system would reach the HEPA filters, where 99 percent of these particulates would be retained.

Reloading error leading to criticality. The highly localized damage postulated to occur following this accident would involve less than 3 percent of the core; melting would release iodine and fission products into the moderator. For this analysis, 50 percent of the iodine and all the noble gases were assumed to become airborne. Before the discharge operation began, the fission products would have decayed for a minimum of 14 hours. However, more fission products would be formed during the postulated criticality accident, and it was conservatively assumed that the fission product content of the core would be the equilibrium concentration at full power.

One-percent core melt due to a loss-of-coolant accident (LOCA). This accident is assumed to result from a double-ended pipe break in one of the six primary lines supplying heavy water to the reactor plenum. To compound this accident, the break is assumed to occur in one of the three primary lines having an emergency cooling-water injection line. Furthermore, a second emergency cooling-water addition system is assumed to be disabled. These assumptions of system operability are consistent with the single-failure criteria used on commercial power plants. SRP reactors are operated at power levels that limit core damage to 1 percent with only one of the three ECS operating. If the ECS operates as designed, no melting would occur. The amount of radioactivity available for release would be 1 percent of the noble gases and the iodine inventories in the core at the time of the accident. All released noble gases are assumed to become airborne. Fifty percent of the released iodine is assumed to become airborne. More than 99 percent of the released iodine would be trapped on the carbon filters; a small fraction would desorb later and be released from the stack.

Probability analysis

The following analyses are provided for each of the four hypothetical accidents:

Moderator spill. A 45,000-liter moderator spill (about 20 percent of the moderator inventory) occurred once at the Savannah River Plant during the early stages of operation. This spill was caused by a valving error while the reactor was shut down. Since then, unnecessary valves have been blanked, and moderator inventory procedures, level detection instrumentation, and leak detection instrumentation have been improved significantly. As a result, the Savannah River Plant has experienced more than 100 reactor-years of operation without a significant moderator spill. Today, the most probable scenario leading to a significant moderator spill is an unnecessary actuation of the ECS. The ECS has never activated; only once in 115 reactor-years of operation was there a spurious combination of reactor alarms and procedures that erroneously indicated the need to actuate the ECS. As a result, alarms and procedures were reanalyzed and improved. If inadvertently actuated, the ECS would result in a significant moderator spill only if the reactor is shut down and contains heat generating assemblies with primary (AC) process water pumps shut down (during reactor operation, moderator pressure at ECS injection points exceeds ECS pressure; the ECS source is restrained by check valves), which occurs about 10 percent of the time. Because of extensive reactor instrumentation that provides a comprehensive status of reactor parameters, components, and systems, an estimated 90-percent probability exists that unnecessary actuation of the ECS will be terminated before the majority of the moderator has been expelled from the reactor. Thus, the estimated probability of spilling most of the moderator is equal to or less than 10^{-4} per reactor-year.

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Discharge mishap. The melting of a fuel or target assembly during discharge would require at least two concurrent failures (for example, a failure of the assembly-holding mechanism on the discharge machine resulting in the dropping of a slug-type assembly plus a failure of the reactor room spray-cooling system, or a failure of the discharge machine drive mechanism resulting in the stalling of the machine plus a failure of four independent sources supplying cooling water to the discharge machine; in the latter case, melting would not necessarily result because the reactor room spray-cooling system could be used to provide cooling if the discharge machine stalls and its cooling-water supplies are lost).

In 115 years of reactor operation, no assembly has been dropped during discharge, indicating that the probability of this event is on the order of 0.01 or less per reactor-year. A review of approximately 250 tests of the reactor room spray system indicates four incidents in which less-than-designed flow was obtained. The system consists of 12 valves with 9 nozzles per valve. In each of the four incidents, the area of the process room receiving a less-than-designed flow was small, approximately 10 percent, indicating that the probability of failure to provide adequate spray cooling to a dropped assembly when called on to function is 0.0016.

More than 300,000 fuel and target assemblies have been discharged without a failure of the discharge machine cooling-water system. The probability of melting an assembly due to failures of both the discharge machine drive mechanism and the cooling system has been estimated to be approximately 7×10^{-5} (Nomm, 1977). Improvement to the discharge machine drive and control system that have been or are being implemented will substantially reduce this probability (by one or two orders of magnitude).

By combining the above probabilities, the estimated probability of melting a fuel or target assembly during discharge is estimated to be less than 10^{-4} per reactor-year.

Reloading error leading to criticality. This type of accident has not occurred at Savannah River Plant.

The reloading error most likely to occur that would lead to a large reactivity increase involves removing a target assembly, failing to replace that assembly with a fresh target, and then removing an adjacent target assembly. The probability of criticality occurring from the removal of so much absorbing material depends on three factors: (1) the probability that the reloading error occurs somewhere in the reactor; (2) the fraction of reactor positions for which the reloading error could produce extreme reactivity changes; and (3) the probability that the reactivity effect could be large enough to achieve criticality. (No damage would occur if the reactor were just critical. The reactivity addition would have to be large enough to achieve significant supercriticality. But to be conservative, this analysis only considers the probability of achieving criticality to be more likely than that of achieving supercriticality. The probability of actual damage would be less than that discussed here.)

Each reactor area has a charge/discharge computer system that monitors for target vacancies, checks the validity of steps in the charge and discharge sequence, and imposes interlocks that require extraordinary actions to bypass key steps. Prior to the installation of the charge/discharge computer system, the

frequency of a double target vacancy was estimated to be about 0.1 per reactor year. Specific charge analyses indicate that about 4×10^{-5} of the postulated double vacancies could result in sufficient reactivity changes to achieve criticality. Thus, without taking credit for protection provided by the charge/discharge computer system, the probability of a double target vacancy resulting in a criticality is estimated to be 4×10^{-6} per reactor-year (Church, 1983).

Protection provided by the charge/discharge computer system has not been evaluated explicitly but should reduce the probability of occurrence by at least a factor of 10 to a value less than 4×10^{-7} (Church, 1983). This is below the probability considered credible. Until the protection provided by the computer system is evaluated explicitly, this accident is considered to define the spectrum of credible events and risks along with the other three accidents discussed in this section.

One-percent core melt due to a loss-of-coolant accident. This type of accident has not occurred at Savannah River Plant. The results of a literature search on pipe breaks in highly pressurized systems (L-Reactor is not a highly pressurized system) indicate probabilities on the order of 3×10^{-5} per year for massive piping failures. The probability of a partial failure of the Emergency Cooling System has been estimated to be 3×10^{-2} . Thus, the probability of the accident occurring with only one operable ECS is less than 1×10^{-6} per reactor-year. (If two ECS systems are operable, there is no damage.)

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The assembly flow rates are computed for these extreme conditions using methods that are normalized to the results of reactor experiments simulating loss-of-coolant-accident conditions. Based on these flow rates, the damage to the reactor core is computed as a function of preincident reactor power. A maximum upper limit is then set on reactor power such that the reactor damage will not exceed 1 percent in the event of a maximum-leak-rate, loss-of-coolant accident coupled with losses of two of the three ECS systems.

Thus, the probability of a loss-of-coolant accident occurring and causing 1-percent core melting is estimated not to exceed 10^{-6} per reactor-year (Church, 1983).

Radiological consequences of reactor accidents

This section describes the techniques used to calculate offsite doses that result from reactor accidents. Appendix G provides a more detailed (NRC, 1979; Pendergast, 1982a,b) description. The calculations are consistent with NRC guidelines for accident analysis. The methods discussed were used for analysis of all accidents, including the moderator spill and fuel melting accidents.

Three parameters are necessary to compute the maximum offsite dose. First, the radioactive source term must be specified, including the release rate and isotope type. Second, the transport of the isotope by the wind must be computed based on appropriate calculational models and meteorological data. Third, the external and internal doses to an individual assumed to be located at the plant boundary are computed based on a standard man, breathing rates, and several parameters related to absorption of energy from a particular isotope.

The release from the stack is assumed to propagate as a Gaussian plume over a 2-hour period, and the exposure of an individual is treated as a time-integrated calculation. Two-hour duration of the meteorology is assumed, and this implies the subject is irradiated for a 2-hour period. This is very conservative because measurements at the SRP site show that the probability of wind persistence for a 2-hour period is, for some directions, only about 20 percent.

The 2-hour irradiation period begins when radioactive material reaches the plant boundary. Both the noble gas and iodine source terms are assumed to have decayed during transport. Decay during the exposure is not included in the calculation.

The source term for iodine is the amount that would penetrate and desorb from the filters in the first 2 hours following the incident. The average iodine retention efficiency assumed for the carbon is that for carbon aged 19 months. This is intended to be typical of normal operation. Carbon beds are replaced on a staggered schedule, so some beds have relatively fresh carbon, some have carbon of intermediate age, and some have carbon approaching its service limit of 30 months.

The downwind concentration of iodine, tritium, and noble gases was calculated according to an integral technique using the computer code NRC145-2. This code was developed at Savannah River Plant and uses a Gaussian plume model based on NRC Regulatory Guide 1.145 (Pendergast, 1982a).

The meteorological data used in the dose calculations were collected from January 1975 through December 1979. The data were obtained at towers near P-, K-, and C-Reactors. Calculations for L-Reactor used data from the closest tower (K-Area). The meteorological data from each tower were averaged for 2-hour periods and sorted into 16 direction sectors, six wind speeds, and seven stability classes. (Stability classes were based on the deviation of the mean wind direction.)

Median meteorological conditions (50th percentile) were assumed in these calculations. Relative doses could be higher under more extreme meteorological conditions, as indicated in Figure 4-9.

Corrections for the topography and jet rise of the released plume are also applied.

Interpolation between 2-hour doses and annual average doses was used to obtain the dose for an extended exposure period of 120 hours, using a method recommended in the NRC Guidelines, incorporated into NRC145-2 (Pendergast, 1982a), and independently verified.

The thyroid dose and the whole-body dose are composed of an inhalation component from iodine, tritium, and a shine component from the gamma emission of the noble gases. The inhalation component was computed by multiplying the isotopic relative concentration by the source strength and dose conversion factors. The shine component integrated the gamma dose from the entire (finite) radioactive plume.

The moderator spill accident considers the tritium dose when the moderator is displaced from the reactor (e.g., due to actuation of the Emergency Cooling

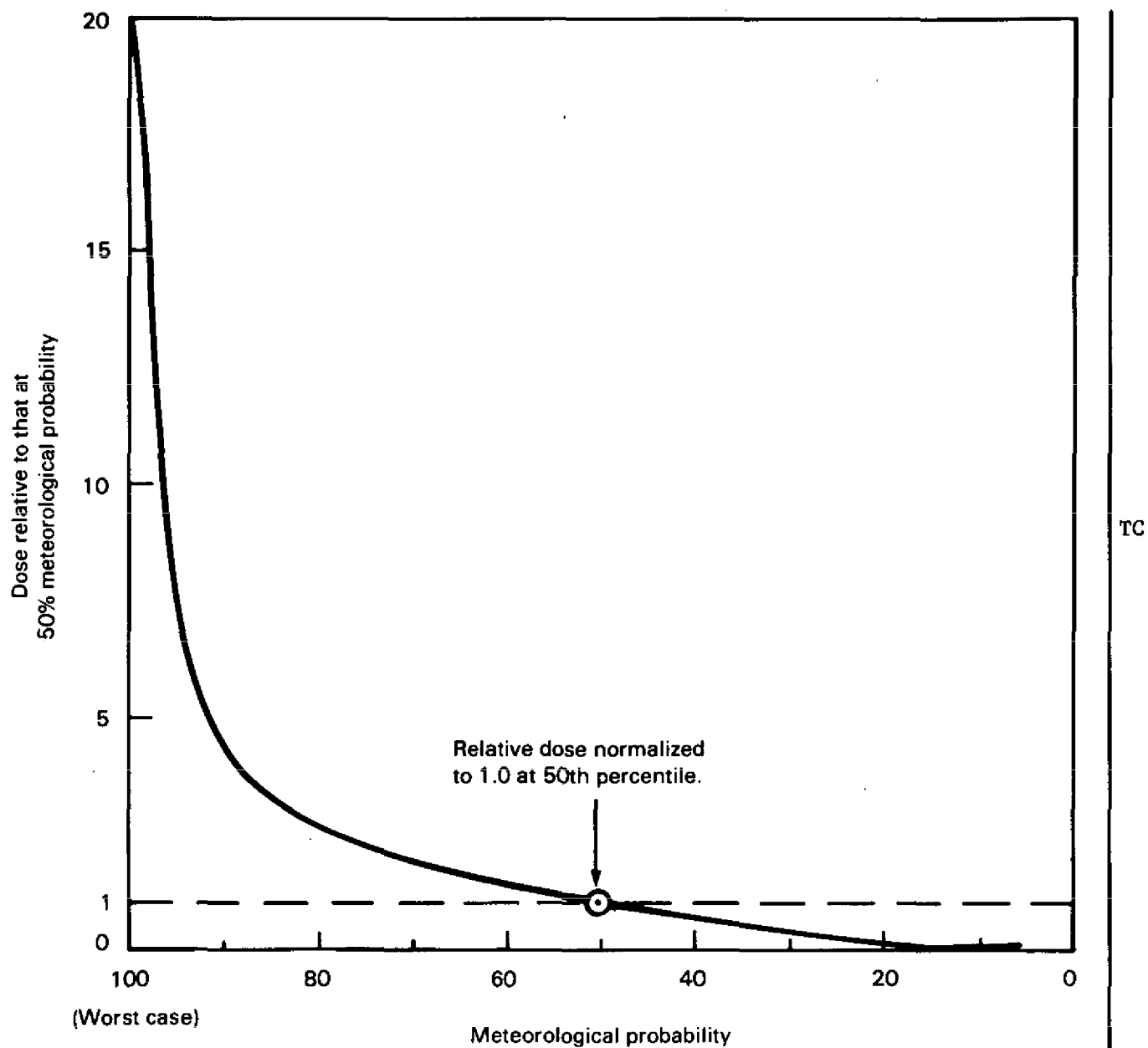


Figure 4-9. Approximate effect of meteorology on boundary dose.

System). The calculation assumes a release of 0.15 megacurie (3 percent of the assumed 5 megacuries tritium inventory in the moderator) over a 2-hour period. The calculated dose to an individual at the plant boundary is shown in Table 4-20.

Table 4-20. Calculated radiation dose to a person at the SRP site boundary following four specific accidents (median meteorology)

Accident	Calculated dose (rem)		
	Whole-body (2 hr) ^a	Thyroid (2 hr)	Thyroid (120 hr)
D ₂ O spill	0.006	-	-
Discharge mishap (one fuel assembly melts)	0.003	0.004	0.01
Reloading error (3% core damage)	0.39	0.51	1.5
LOCA (1% core damage)	0.13	0.17	0.50

^aThe 2-hour whole-body dose is essentially the same as the accident-duration whole-body dose.

The discharge mishap accident assumes that an irradiated fuel assembly, having decayed for 14 hours after shutdown, melts while being discharged. The calculated dose to an individual at the plant boundary is shown in Table 4-20.

As discussed above, calculations indicate that the maximum hazard for a reloading accident would involve less than 3 percent of the core inventory of fission products. The fission product content of the core is assumed to be the equilibrium concentration that would be obtained at full power. Table 4-20 lists the calculated dose to an individual at the plant boundary.

The 1-percent core-melt accident assumes that a massive double-ended pipe break occurs. Thus, 1 percent of core fission product inventory as well as heavy-water coolant is released. Table 4-20 lists the calculated dose to an individual at the plant boundary.

In summary, these offsite doses from postulated accidents were calculated in accordance with accepted methods and assumptions. Appendix G describes offsite doses from particulates. These doses do not exceed DOE radiation protection standards (DOE 5480.1a.1, Chapter 11) for normal operation.

Releases to ground water and surface water

No significant releases to ground water or surface water would be expected from reactor accidents. In the event of a loss-of-primary-coolant or a loss-of-pumping accident, the reactor scrams and the emergency cooling system forces as much as 53,000 liters of water per minute into the reactor to remove decay heat from the core. This water displaces the heavy water, then continues to flow through the reactor.

Overflow from the reactor is pumped to one of two holding tanks that are part of the confinement system. The first tank has a capacity of 225,000 liters and will retain essentially all of the displaced heavy water and its associated tritium. When this tank is full, any subsequent flow bypasses the tank at an upstream overflow point and flows to a 1.9-million-liter tank located in a 190-million-liter earthen basin.

If ECS flow has to continue until the larger tank is full (e.g., for a large primary coolant leak that cannot be isolated), subsequent flow bypasses the tank at an upstream overflow point and enters the earthen basin.

Air that is displaced as the tanks fill with water passes through vent lines and joins the ventilation air that is exhausted through the confinement filters to the 61-meter stack.

If core damage occurs during these severe accidents (less than 1-percent melting is calculated to occur for a large pipe break with only one of three ECS systems operable), fission products would be released to the emergency coolant flowing through the reactor. Any melting would occur in the first minutes of an accident while the decay heat is high and stable ECS flow is being established.

Volatile fission products would be released into the confinement ventilation system; the remainder of the fission products would be retained in the two tanks, which hold a total of more than 10 times the volume of the primary coolant. Any water flowing to the earthen basin after the tanks are full would have passed through a well-cooled, well-flushed core and would be essentially free of radioactivity. For the highly unlikely case of delayed melting after the tanks are full, the noble gases and radioiodine could be carried to the 190-million-liter basin where they could be released directly to the atmosphere. In this case, the iodine would cause increased offsite thyroid doses. Because of the extremely low probability of delayed core damage, no additional dose risk is attributed to this accident.

Risk considerations

The foregoing descriptions have dealt with both the frequency (or likelihood of occurrence) of accidents and their offsite dose impacts (or consequences). Because the ranges of both factors might be quite broad, it is useful to combine them to obtain average measures of environmental risk. Such averages can be particularly instructive as an aid to the comparison of radiological risks associated with accident releases and with natural sources of radiation.

A common way in which this combination of factors is used to estimate risk is to multiply the probabilities by the consequences. The resultant risk is then expressed as a magnitude of consequences expected per unit of time. Table 4-21 lists the estimated whole-body risks associated with the four postulated accidents described in this section. These risks were calculated by multiplying the calculated whole-body doses in Table 4-20 by the corresponding accident probabilities in Table 4-22; they range from 10^{-4} to 10^{-3} millirem per reactor-year. All risk values are much less than the risk that would be associated with a natural radiation dose of 93 millirem per year.

Table 4-21. Risk evaluation of postulated serious accidents

Accident	Consequence ^a (mrem)	Probability (y^{-1}) per reactor- year	Expected whole- body risk (mrem/reactor- year)
Moderator spill	6	10^{-4}	6×10^{-4}
Discharge mishap	3	10^{-4}	3×10^{-4}
Reloading error	390	4.0×10^{-7}	1.6×10^{-4}
LOCA, resulting in 1% core melt	130	10^{-6}	1.3×10^{-4}

^aThe 2-hour whole-body dose is essentially the same as the accident-duration whole-body dose.

4.2.1.5 Assessment of severe hypothetical accidents

TC | Any accident that results in damage greater than the maximum calculated for
the accidents described above (3-percent core melt) is highly improbable. As
discussed in more detail in Appendix G and in the Safety Analysis Report (Du
Pont, 1983a), analyses of hypothetical SRP reactor accidents indicate that the
probability of an accident of a higher consequence than a 3-percent core melt
is extremely low. The estimated probability of accident sequences that would
result in melting as much as 100 percent of the reactor core is on the order of
TC | 10^{-8} per reactor-year. For this analysis, the Airborne Activity Confinement
System is expected to continue to function properly because it is already online
before the accident, includes redundant primary components and diverse backup
power supplies, and has a high tolerance to severe accidents (Du Pont, 1983a).
TC | As an added safety measure, a Confinement Heat Removal System has been installed
to reduce the possibility of confinement failure in the extremely unlikely event
of a full core-melt accident. However, to assess the consequences of core melt-
ing for a highly improbable sequence of events, a 10-percent melt accident is
postulated. Based on the discussion for the accidents with lesser consequences,
the probability of a 10-percent core melt would be between 10^{-6} and 10^{-8} per
reactor-year.

TC | To analyze the consequences of accidents having very low probability, an
evaluation independent of the SAR (Du Pont, 1983a) was performed using the com-
puter model, CRAC2, employed by NRC to evaluate core-melt accident consequences
in its Environmental Impact Statements (NUREG/CR-2901). This model considers
the probability of occurrence of each of 29 meteorological conditions based on
site data, population distributions as far as 800 kilometers from the site, and
a number of options for mitigation of consequences that were not exercised in
this evaluation. The model calculates exposures to individuals and populations
from (1) direct radiation from the passing plume and material deposited on the
ground, (2) inhalation, and (3) consumption of contaminated foods and milk.
Finally, the model produces consequence-probability distribution curves (called
complementary cumulative distribution functions, or CCDFs) for various doses,
for prompt and delayed fatalities, and for economic costs (see Appendix G).

An examination of the results of these calculations must recognize that there are a number of differences between the CRAC2 methodology and the method that has been normalized to SRP conditions to arrive at the doses presented in Section 4.2.1.4. For example, mean doses determined by CRAC2 are not directly comparable to the median (or fiftieth percentile) meteorological condition employed for the doses in Section 4.2.1.4. Also, CRAC2 dose pathways include small doses from ground-deposited material, food pathways, and inhalation of resuspended radionuclides not considered in the other dose values. Other differences exist in the net effectiveness assumed for iodine retention by the charcoal filters, the duration of the releases, site boundary distances, meteorological data base, and the population data year chosen. Despite these differences in methodology and assumptions, the results are in good agreement.

Dose and health impacts

Calculations using the CRAC2 code show that, for the hypothetical 10-percent core-melt accident, there are no cases of early fatalities, no cases where the whole-body dose exceeds 25 rem, and no cases where the thyroid dose exceeds 300 rem (10 CFR 100 siting criteria). The mean value for the site boundary whole-body dose is 0.35 rem and the expected peak value (i.e., for the most improbable meteorological condition sampled) is 1.7 rem. The mean value for the site boundary thyroid dose is 1.7 rem with a peak value of 11.7 rem.

Figure 4-10 displays the calculated CCDF for latent cancer fatalities. The mean number of cancer fatalities (including thyroid cancers) is 2.4 and the peak is 20 with a conditional probability (i.e., assuming the accident has occurred) of 1.4×10^{-4} per reactor-year. (Excluding thyroid cancers, the mean number of latent cancer fatalities is 1.0 and the peak number is 15.) When the probability of a 10-percent core-melt accident (10^{-6} to 10^{-8}) is taken into account, the mean number of latent fatalities is, conservatively, 2.4×10^{-6} per reactor-year or an average of one death per 400,000 reactor-years of operation.

Figure 4-11 displays the CCDFs for total population whole-body exposure in person-rem, that is, the conditional probability that the total population exposure will equal or exceed the values given. The peak population exposure is 2.4×10^5 person-rem with a conditional probability of 1.1×10^{-4} and the mean value is 1.6×10^4 person-rem for the population within 800 kilometers of the reactor site, and 7.7×10^3 person-rem for the population within 80 kilometers of the reactor site. Again, if the probability of an accident with a 10-percent core melt (10^{-6} to 10^{-8}) is taken into account, the mean value for total exposure for the population within 80 kilometers is, conservatively, 7.7×10^{-3} person-rem per reactor-year. For perspective, this can be compared to a whole-body dose from natural background radiation of 8×10^4 person-rem per year for the population in question.

Economic and social impacts

The offsite economic impact of a reactor accident is calculated as a probability distribution for the cost of offsite mitigating actions. The factors contributing to these estimated costs include the following:

- The value of crops contaminated and condemned
- The value of milk contaminated and condemned

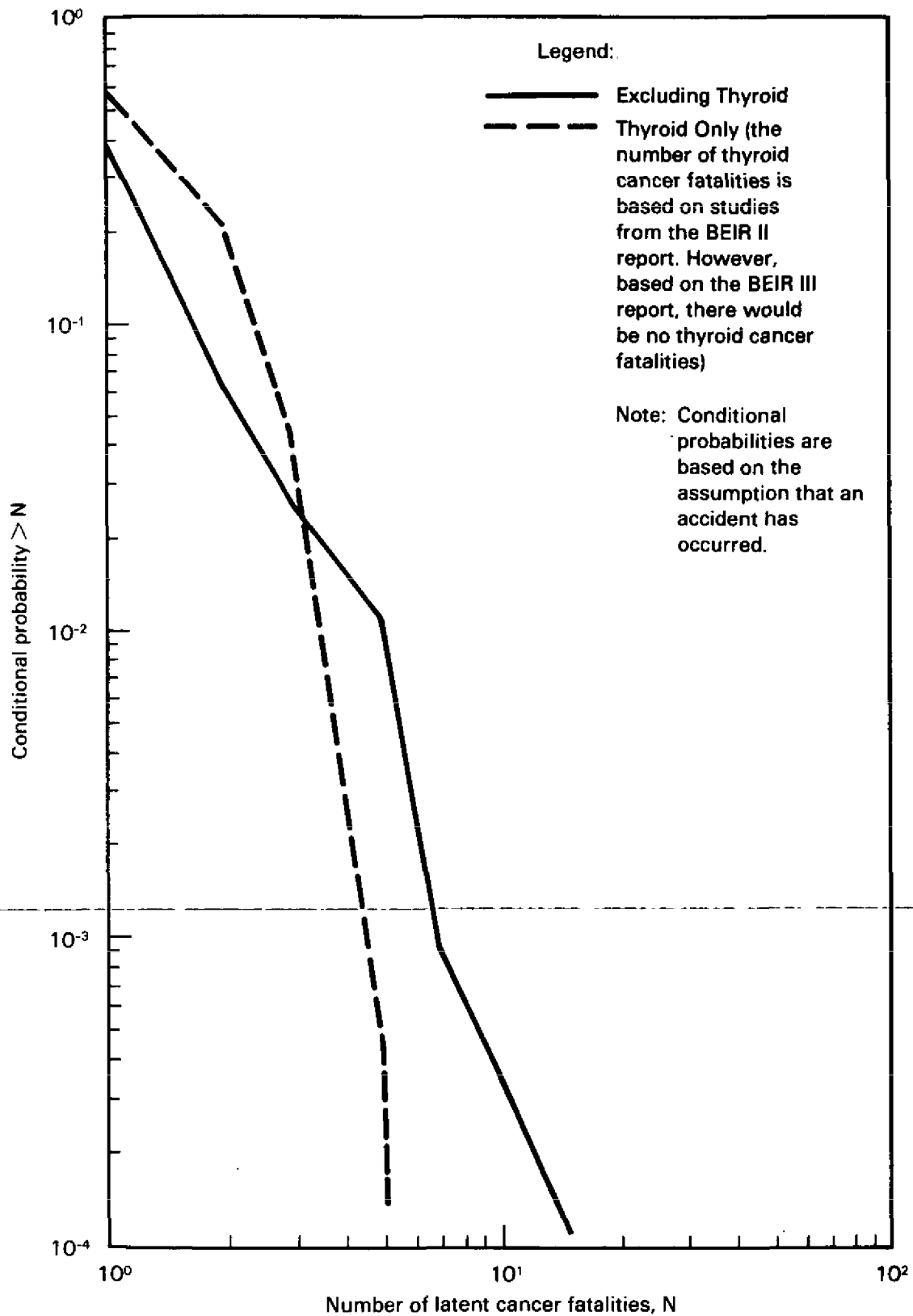


Figure 4-10. CCDFs for latent cancer fatalities in a hypothetical 10-percent core meltdown as calculated with the CRAC2 code.

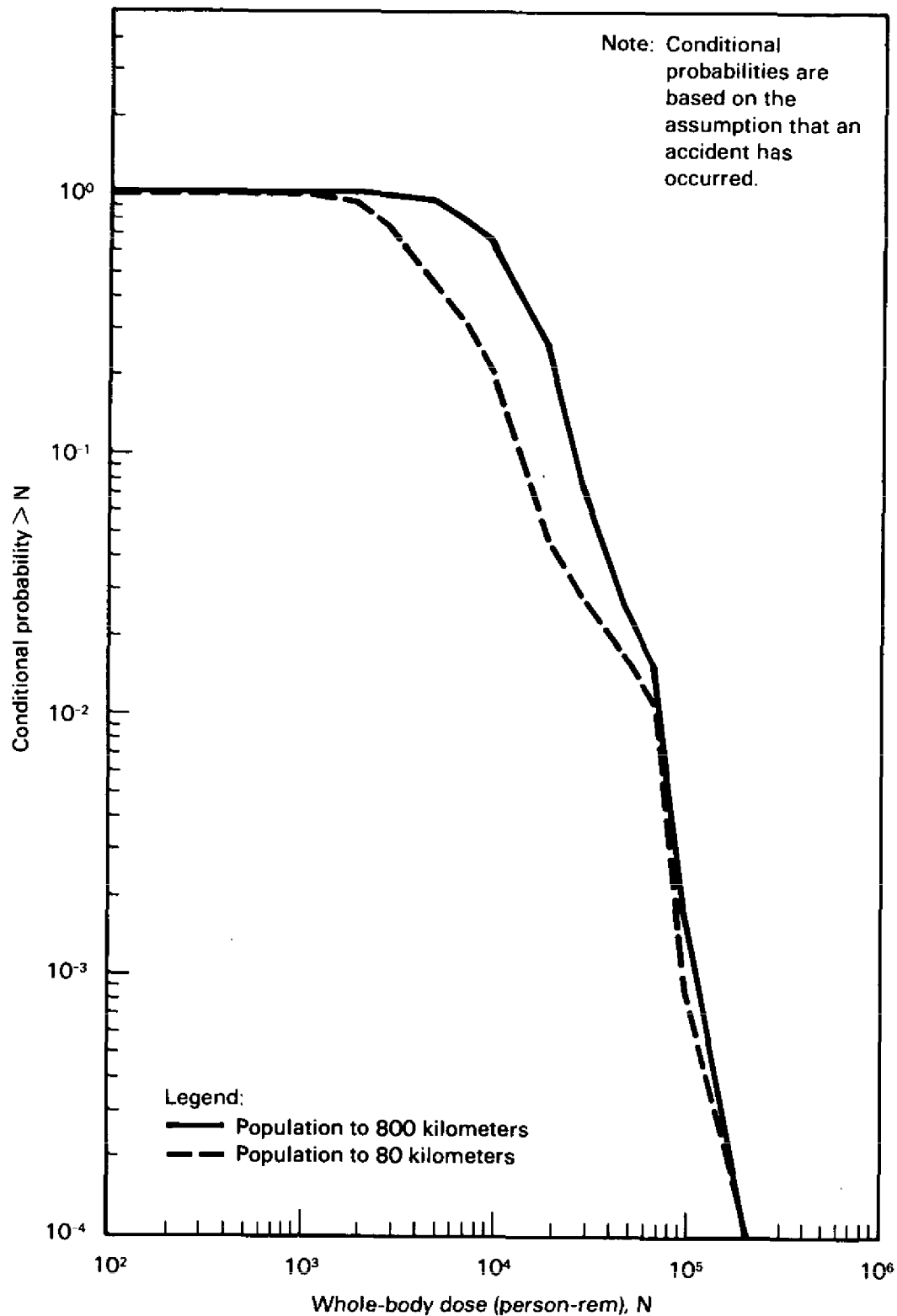


Figure 4-11. CCDF for whole-body person-rem doses in a hypothetical 10-percent core meltdown, as calculated with the CRAC2 code.

- Costs of decontamination of property where practical
- Indirect costs due to loss of use of property and incomes derived therefrom

The last cost would derive from the necessity for interdiction to prevent the use of property (i.e., farm crops, etc.) until it is either free of contamination or can be economically decontaminated.

The mean offsite economic risk from an accident where 10 percent of the core melts is \$73,000 and the peak cost is $\$1.7 \times 10^6$ at a conditional probability of 2.4×10^{-4} . For comparison, the cost of property damage due to automobile accidents for the area of a circle with a radius of 80 kilometers is $\$1.3 \times 10^7$ per year and the property damage due to fires for the same area is $\$5.5 \times 10^6$ per year.

Table 4-22 summarizes all the consequences from a postulated 10-percent core-melt accident.

Table 4-22. Consequences from a postulated accident resulting in 10-percent core melt^a

Consequence	Mean value	Peak value
Early fatalities	0	0
People with whole-body dose of 25 rem	0	0
People with thyroid dose of 300 rem	0	0
Latent-cancer fatalities (excluding thyroid)	1.0	14.9
Thyroid-cancer fatalities	1.4	5.2
Site boundary whole-body dose (rem)	0.35	1.7
Site boundary thyroid dose (rem)	1.7	11.7
Population whole-body dose (person-rem) (population to 80 kilometers)	7.7×10^3	2.4×10^5
Population whole body dose (person-rem) (population to 800 kilometers)	1.6×10^4	2.4×10^5
Population thyroid dose (person-rem) (population to 80 kilometers)	8.6×10^4	3.6×10^5
Population thyroid dose (person-rem) (population to 800 kilometers)	1.0×10^5	3.8×10^5

^aHypothetical 10-percent core melt as calculated with CRAC2 code.

TC| The probability of a 10-percent core melt is estimated to be less than 10^{-6} .

Table 4-23 shows average values of risk associated with population dose, early fatalities, latent fatalities, and costs for early evacuation and other protective actions, which have been calculated for a 10-percent core melt. These average values are obtained by summing the probabilities multiplied by the consequences over the entire range of the distributions. Because the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

Table 4-23. Average values of environmental risks due to a 10-percent core melt, per reactor-year^a

Offsite risk	Value
Population exposure	
Person-rem within 80 kilometers	7.7×10^{-3}
Person-rem total	1.6×10^{-2}
Early fatalities	0.0
Latent cancer fatalities	
All organs excluding thyroid	1.0×10^{-6}
Thyroid only	1.4×10^{-6}
Cost (dollars) of protective actions and decontamination	7.3×10^4

^aHypothetical 10-percent core melt as calculated by the CRAC2 code. The probability of a 10-percent core melt is estimated to be less than 10^{-6} .

4.2.1.6 Total risk from all postulated reactor accidents

To provide a perspective of the overall reactor accident risk on the Savannah River Plant and of L-Reactor operation, Figure 4-12 shows preliminary total probability curves that present the annual probability of a resident living at the SRP site boundary receiving more than a certain dose from postulated accidents (see Section G.5.7.3). These results are based on accident analyses presented in the Safety Analysis Report and a supporting document (Du Pont, 1983a; Church, 1983), including less severe accidents at the high end of the probability spectrum and an assumed hypothetical 100-percent core melt at the upper bound of the consequences spectrum (see also Section G.5.7.3). Six different accident initiators were considered. For all the accidents, the most probable outcome would be no reactor damage. For the six accidents, only 11 postulated, but highly improbable, sequences resulted in significant amounts of reactor core damage (ranging from 1 percent to 100 percent). For the postulated 100-percent core-damage accidents (sequences 2, 3, 4, and 6 below), Figure 4-12 also reflects the failure of the Confinement Heat Removal System. These accident sequences were as follows:

1. A loss-of-coolant accident with only one operable ECS.
2. A loss-of-coolant accident with a total failure of the ECS.
3. The withdrawal of a single control rod or a gang of control rods with a failure of both the safety-rod scram and the ABS-SC.
4. Loss of coolant to a single target assembly with a failure of both the safety-rod scram and the ABS-SC.
5. A loss-of-pumping accident with only one operable ECS.
6. A loss-of-pumping accident with a total failure of the ECS.

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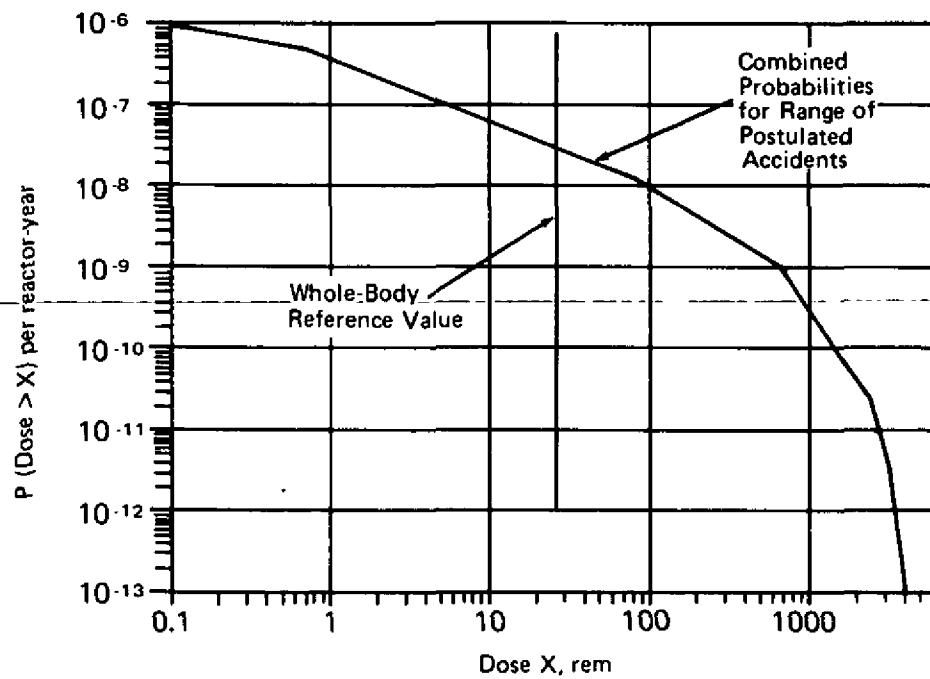
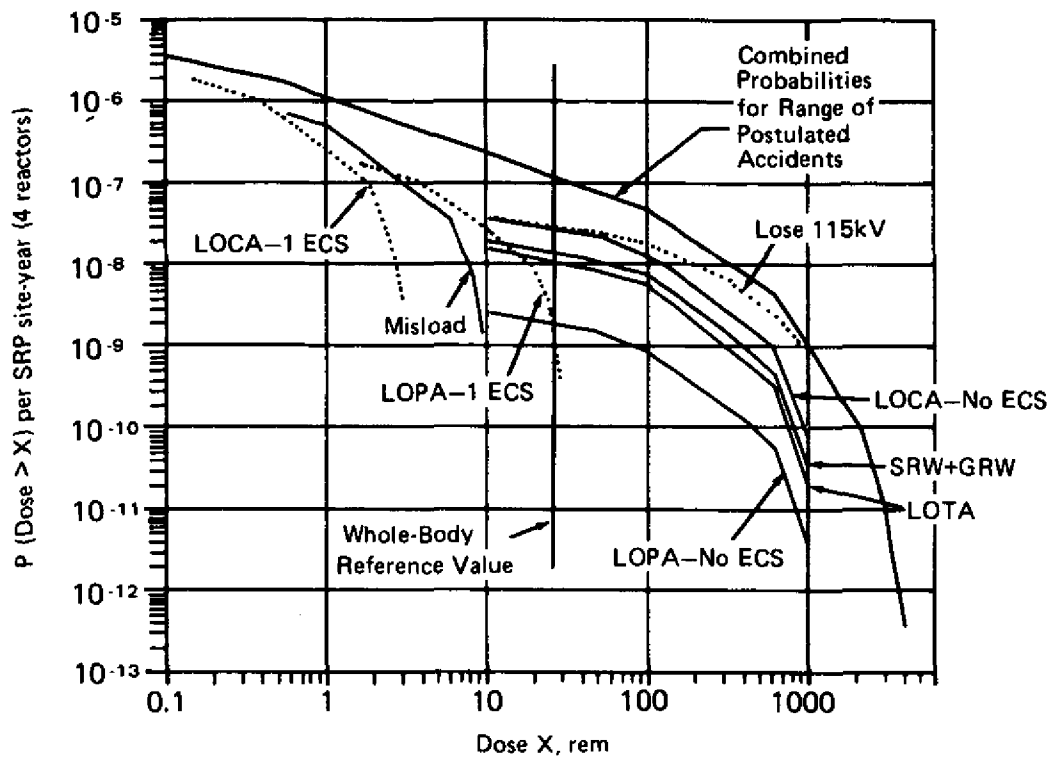


Figure 4-12. Total probability (P) per SRP site-year (upper) and reactor year (lower) that the whole body dose to a person on the plant boundary will exceed a specified value, X rem.

7. A reloading error during charge/discharge operations making the reactor supercritical.
- 8-11. Extended total loss of offsite (commercial) power together with extended loss of onsite generating capability. This sequence would affect all reactors and is postulated to result in core damage to 1, 2, 3, or 4 reactors.

The computed offsite doses for the loss-of-coolant accident with 1 percent core damage and the reloading error with 3-percent core damage are listed in Table 4-20 for median meteorology (conditions for which the more severe meteorological conditions are not exceeded 50 percent of the time). The relative doses for other meteorological frequencies are shown in Figure 4-9. Doses for postulated core damage greater than 1 percent would be proportional to the dose for 1-percent damage.

The probability of occurrence of an accident sequence was combined with the data for meteorological probability versus offsite dose for each of the above 11 sequences. Then, for a given dose rate, the occurrence probabilities were combined to obtain an overall probability per reactor-year of exceeding a given dose. This overall dose probability curve is shown in Figure 4-12. The results are consistent with (1) the decreasing frequency of meteorological conditions that give higher doses for any accident (Figure 4-9), and (2) the extremely low probability of accidents occurring with core damage exceeding 3 percent.

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The implementation of reactor safety programs has reduced the probability of occurrence of accidents to extremely low levels. Figure 4-12 indicates that the probability of exceeding the Nuclear Regulatory Commission site whole-body dose criteria for commercial power reactors (10 CFR 100) of 25 rem at the site boundary in accident situations is extremely low (less than 10^{-7} per year), even in the most severe hypothetical accidents.

The traditional approach to SRP reactor safety analysis addressed the consequences for "worst-case credible" (and even some "noncredible") accidents based on the single-failure criterion. This criterion assumes that the initial accident is compounded by the failure of the single-most-important active component designed to mitigate the accident. (An active component is one that must change its state to perform its duty; e.g., a valve must be realigned.) The initiation of the accident and the failure of the component were considered without regard to the actual probability of their occurrence. Results from the preliminary risk evaluation of the accident sequences discussed above support earlier evaluations made for worst-case scenarios using single-failure criteria, which concluded that there is negligible risk to public health and safety.

4.2.2 Non-nuclear hazards and natural phenomena

4.2.2.1 Toxic-gas release

During prior reactor operations, the effects of toxic-gas releases were analyzed, and provisions were made for shutdown, building evacuation, and remote control of coolant flow pumps and valves. The two toxic gases considered were the chlorine used to prevent biofouling of reactor heat exchangers and the

hydrogen sulfide used in the heavy-water production area. Two recent changes in plant operation have essentially eliminated any hazards from these gases:

1. L-Reactor would use sodium hypochlorite rather than chlorine as the cooling-water biocide. Sodium hypochlorite presents no toxic-gas health hazard to reactor operation and would provide the same biofouling inhibition as chlorine.
2. Heavy-water production at the Savannah River Plant has stopped. The large quantities of hydrogen-sulfide gas stored in the heavy-water production area have been removed.

4.2.2.2 Fire

The presence of flammable materials in the reactor building is strictly controlled, so the probability of a large fire is low. Because of redundancies in shutdown, a fire (e.g., in an electrical cable tray) will not prevent a safe shutdown. Analyses performed (Du Pont, 1983a) for L-Reactor startup did not find any credible fire hazard that would result in a release of radioactivity. The only fire-related incident deemed credible was the possibility of extended downtime and repair costs, but no specific cause for such a fire was identified.

In addition to normal operating personnel who are instructed in basic fire fighting, a fully trained and equipped fire department is maintained at Savannah River Plant.

A large cleared area surrounding the reactor building protects against hazards from a forest fire. Smoke from a forest fire could require temporary evacuation of L-Reactor. However, normal and emergency facilities are provided to maintain safe conditions, and the reactor could also be shut down and maintained in a safe shutdown condition from the remote control station.

4.2.2.3 Earthquakes

As noted in Section 3.3.2, there are no known capable faults within 300 kilometers of the L-Reactor site, except perhaps the geophysically inferred faults in the meizoseismal area of the 1886 Charleston earthquake (Du Pont, 1980; Georgia Power Company, 1982). No reservoir-induced seismicity is associated with Par Pond, which is located about 6.5 kilometers northeast of L-Reactor.

Probabilistic and deterministic analyses, commensurate with the criteria used by the NRC in 10 CFR 100, have determined that the maximum seismic hazard at the Savannah River Plant is due to a Modified Mercalli Intensity MMI; Langley and Marter, 1973) of VII (magnitude 5.0 to 5.5) earthquake in the immediate vicinity of Savannah River Plant or a postulated MMI = X (magnitude 6.6) earthquake near Bowman, South Carolina, 95 kilometers from Savannah River Plant. In both cases, the expected site MMI = VII corresponds to a peak horizontal free field acceleration of about 0.10g (Du Pont, 1982a). A design-basis earthquake acceleration of 0.20g has been established for design and analysis of key

seismic-resistant buildings, systems, and components at Savannah River Plant. This design acceleration is predicted to be exceeded only once in 5000 years (Du Pont, 1982a).

Studies performed by Rutledge (1976) and D'Appolonia (Du Pont, 1980) show that earthquake ($\leq 0.20g$)-induced liquefaction is not a potential problem for L-Reactor and other SRP facilities located on the Aiken Plateau (cf., Langley and Marter, 1973, and Figure F-1).

The foundation investigations for L-Reactor were performed by the U.S. Army Corps of Engineers (COE, 1952a). At their recommendation, a soil grouting program was undertaken to improve subsurface conditions (COE, 1952b). A number of earthquake-engineering investigations have been performed to establish earthquake-design criteria and to recommend modifications to component design (e.g., Du Pont, 1968; List, 1969; Rutledge, 1976; Geotechnical Engineers, Inc., 1979; URS/JAB, 1982a,b,c).

The reactor buildings are heavy, blast-resistant, concrete structures. Several earthquake-engineering improvements have been made at P-, C-, and K-Reactors to meet the seismic criteria for a design basis earthquake of $0.20g$. These improvements were also made in the L-Reactor upgrade and include the following:

- Providing additional seismic bracing on the actuator tower to reduce its dynamic response to earthquake excitation
- Strengthening the 61-meter building exhaust stack
- Improving the lateral support for the emergency cooling-system piping and the supplementary safety system (neutron poison injection system) piping
- Improving the anchors on the 12 track-mounted process heat exchangers

An earthquake monitoring system will automatically alarm at $0.002g$ and shut down the reactor when the earthquake excitation reaches $0.02g$ (one-tenth the design-basis value). In more than 28 years of reactor operation there has never been a seismic alarm.

4.2.2.4 Tornado and hurricane effects

The SRP site lies within tornado risk region B (Twisdale and Dunn, 1981) with an occurrence rate of about 2.69×10^{-4} per square kilometer per year corrected for unreported tornadoes. Based on this study and on work by Reinhold and Ellingwood (1982), the probabilities of a tornado striking a point at Savannah River Plant are calculated for the midpoint characteristics of the Fujita-tornado intensity scale (F-scale); the results are presented in Table 4-24. In addition, this table provides the probability of striking a building as large as L-Reactor at the SRP site. Risks are extremely low.

TC

Hurricanes that occur along the South Carolina coast generally will not subject the Savannah River Plant to winds in the whole-gale to hurricane range

Table 4-24. Annual probabilities of a tornado strike at L-Reactor for midpoints of the Fujita tornado intensity scale

Fujita intensity scale	Wind speed ^a (m/sec)	Annual probability of a tornado strike at L-Reactor ^b
F-0	16.1	7.79×10^{-4}
F-1	41.4	3.52×10^{-4}
F-2	60.4	1.65×10^{-4}
F-3	81.4	5.35×10^{-5}
F-4	104.4	1.58×10^{-5}
F-5	129.4	2.61×10^{-6}
F-6	156.2	3.01×10^{-7}

^aWind speeds are reported for the midpoints of the Fujita tornado intensity categories.

^bBased on an occurrence rate of 2.69×10^{-4} tornadoes per square kilometer per year (Reinhold and Ellingwood, 1982, Tables 16 and 17), and an L-Reactor building width of 170 meters.

because Savannah River Plant is approximately 160 kilometers inland, and the high winds associated with hurricanes tend to diminish as the storms move over land. Winds of 33.5 meters per second were measured once by anemometers mounted at the 61-meter level of the WJBF-TV tower during the history of Savannah River Plant, as Hurricane Gracie passed north of the plant site in September 1959. At Augusta, Georgia, the fastest 1-minute wind speed for the 1950-1978 period of record was 37.1 meters per second (corrected to an anemometer height of 10 meters). The return periods for 1-minute wind speeds at Augusta are reported in Table 4-25.

Table 4-25. Return of 1-minute wind speeds at Augusta, Georgia

Return period (years)	Wind speed (m/sec)
100	37.1
1,000	46.9
10,000	56.8
100,000	66.2

The L-Reactor building is a concrete structure that is blast-resistant to a pressure of about 50,000 pascals. Its weakest structural area, the disassembly area, can withstand a tornado-induced pressure drop of 20,700 pascals (Yau and Zeh, 1976), twice that created by an intensity F-5 tornado (a very low probability event; see Table 4-24).

The 61-meter-tall ventilation exhaust stack at L-Reactor is designed to withstand a 1-in-10,000 year event (see Table 4-25) with winds of 56 meters per second. However, if the stack should fall, it would not strike a portion of the reactor that would impair the ability to shut down the reactor or maintain cooling capabilities.

The resistance of the L-Reactor building to wind-driven missiles was analyzed by Yau and Zeh (1976) as part of a study to determine the tornado resistance of the reactor building. The greatest penetration of the concrete reactor building was calculated to be caused by a 30-centimeter steel pipe; less than 40 percent of the wall thickness of the disassembly area wall was calculated to be penetrated by the pipe.

Because the disassembly area is structurally the weakest part of the reactor building, the rest of the building was also deemed safe from penetration by the postulated missiles. The probability of tornado missiles passing through exterior doors, ducts, vents, or other openings that are not tornado resistant is negligibly small.

Damage to the 61-meter-tall stack, confinement system filter compartments, and other parts of the building that are not resistant to tornados would not cause, directly or indirectly, a reactor accident. A tornado strike causing damage to the filter compartments or the stack after an independently caused reactor accident would increase offsite dose effects. Such multiple-series accidents are not considered in this analysis because of the extremely low probability of a tornado striking the reactor immediately following a reactor accident.

Emergency power capabilities at L-Reactor are sufficient to maintain the reactor in a safe shutdown condition if outside power is lost during a severe weather disturbance.

4.2.2.5 Floods

As noted in Section 3.4.1, L-Reactor (floor elevation of 76.5 meters) is situated well above (1) the maximum historical flood stage of 36 meters and (2) the flood stage of 43.6 meters calculated to result from the domino failure of Savannah River dams above the SRP. Flooding of these magnitudes could cause the loss of the river pumphouses supplying cooling water, and of external electrical power. However, onsite storage of cooling water (9.5×10^4 cubic meters) is, with partial recirculation, adequate to remove heat during shutdown, and on-site emergency power generation would maintain the reactor in a safe shutdown condition.

Because of the geographic location of the site, the formation of significant amounts of ice on streams and rivers occurs rarely. A review of Augusta, Georgia, newspaper accounts dating back to approximately 1800 indicates that the formation of ice jams on the Savannah River occurred in 1827 and 1886. Neither event resulted in reported flooding (Du Pont, 1980).

The L-Area is not subject to local flooding. Pen Branch to the west and north, and Steel Creek to the east and south provide adequate drainage. Opposite L-Reactor these streams are at least 15 meters below the reactor floor elevation under normal flow conditions.

4.3 TRANSPORTATION

4.3.1 Onsite and offsite shipments

Onsite

The proposed restart of L-Reactor would increase the total number of onsite shipments by an amount typical of the individual reactor areas now operating. Rail shipments of irradiated fuel from the reactor to the separations plants could be made with existing casks and equipment using current rail crews. Truck shipments involving unirradiated reactor fuel, deionizer casks, and wastes could also be made with existing equipment using the SRP traffic and transportation (T&T) crews currently assigned to these tasks. Higher volume shipments, such as scrap metal, waste dumpsters, and D₂O drums, would require purchase of additional equipment and a modest increase in T&T crews. Also, the operation of L-Area would require about the same number of nonradioactive shipments by T&T and vendor trucks as the other individual reactor areas. No significant impact on SRP transportation systems is expected from the operation of L-Area.

Shipments on the SRP rail system would include the following:

1. Empty casks to transport reactor fuel elements.
2. Intact irradiated fuel in 70-ton casks (CD casks) on flatbed railcars to 200-F or 200-H areas.
3. Any irradiated fuel with cladding defects in a special containment device ("harp") within a 55-ton failed fuel element cask to a 200-Area.
4. Occasional containers of helium or Polybor or other nonradioactive materials.

Onsite truck shipments for L-Area would include the following:

1. Unirradiated fuel in steel shipping boxes and other reactor lattice components from the 300-M area.
2. Irradiated lithium-aluminum control rods and blanket assemblies in a 45-ton cask on a flatbed trailer from the L-Area disassembly basin to 200-H area.
3. Irradiated scrap metal in a 15-ton cask or replacement cask from the L-Area disassembly basin to the SRP burial ground (about 80 shipments annually).

4. Moderator (D₂O) in stainless steel 55-gallon drums to and from other reactor areas and the 400-D area where contaminant removal and purification facilities are located (about 700 drums annually).
5. D₂O purification deionizers from 100-L area. After the resin is depleted, the deionizer would be shipped to 100-K area in a cask on a special flatbed trailer for dedeuterization before being shipped to the burial ground (about three annually). A replacement D₂O equilibrated purification deionizer would be shipped concurrently from 100-K to 100-L area.
6. Basin water deionizers mounted in casks on a special trailer to Building 245-H area for regeneration and return to L-Area service (about five annually).
7. Liquid and gas samples on a pickup truck to laboratories on each shift.
8. Dry wastes in collection pans on a daily basis and boxes of wastes intermittently generated during jobs such as replacing containment filters to the SRP burial ground.
9. Liquid light-water wastes to the underground storage tank in 100-C area (infrequently) or, when volumes are large, to F-Area waste management tanks, in an unshielded tank trailer.
10. Nonradioactive materials to L-Area on Savannah River Plant or vendor trucks.

Offsite

Shipments from off the site to support L-Area operation would include petroleum distillate products from major distribution terminals in Augusta, Georgia, and Aiken County, South Carolina; chemicals from normal distribution points; solid depleted uranium and 1.1-percent uranium-235 from the Feed Materials Production Center in Fernald, Ohio; and highly enriched uranium metal billets from the Y-12 plant in Oak Ridge, Tennessee. The latter shipments would be safeguarded (see Section 4.3.2.2). Operation of L-Reactor would increase the amount of plutonium metal shipped offsite from Savannah River Plant in special safeguarded Department of Energy (DOE) vehicles and also would increase the number of DOE-escorted shipments of uranyl nitrate hexahydrate solution shipments to the Y-12 plant in Oak Ridge, Tennessee.

These offsite shipments of nuclear and other hazardous materials would be subject to the same Department of Transportation (DOT) regulations (49 CFR 170-179) as other similar cargo already in commerce.

Primary reliance for safety in the transport of hazardous materials, including nuclear material, is placed on the packaging. The nuclear packaging standards are established by DOT, DOE Orders, and some of the states through which materials are transshipped. These standards are established according to the type and form of material for containment, shielding, nuclear criticality safety, and heat dissipation. The standards for nuclear materials provide that the packaging shall prevent the loss or dispersal of the radioactive contents, retain shielding efficiency, assure nuclear criticality safety, and provide

adequate heat dissipation under normal conditions of transport and under specified accident damage test conditions (i.e., the design-basis accident). The quantity of material contained in packages not designed to withstand accidents is limited, thereby limiting the risk from releases that could occur in an accident. The quantity of material contained in a shipping package also must be limited so that the standards for external radiation levels, temperature, pressure, and containment are not exceeded.

Protection of the public from external radiation is provided by limitations on the radiation levels at the surface of, and at specified distances from, the outside of packages of nuclear materials and by storage and segregation provisions for such packages in transit. The number of packages in a single vehicle or area is limited to control the aggregate radiation level and to ensure nuclear criticality safety in the event of conceivable accidents. In addition, shipments of special nuclear materials such as plutonium and enriched uranium are safeguarded against theft or sabotage by use of DOE equipment and DOE couriers.

Nuclear materials shipped offsite are packaged by the operating contractor as required by DOT specifications with a DOE- or NRC-approved certificate of compliance for the packaging selected. The packaged material is transferred to the custody of DOE-SR, which becomes the consignor for the shipment.

Pollutant emissions

Pollutants would be released to the atmosphere from transportation operations associated with the L-Reactor operation. Table 4-26 lists the pollutant emissions from vehicles associated with L-Reactor operation that would occur both on and off the Savannah River Plant.

Table 4-26. Transportation-related nonradiological emission of pollutants associated with L-Reactor operation^a

	Cars and light trucks	Trucks less than 10 tons	Trucks ^b off SRP site
Fuel	gasoline	diesel	diesel
Annual fuel consumption (liters)	147,600	64,300	199,900
Kilometers traveled per year	643,600	290,000	491,000
Annual emissions (kg)			
Particulates	215	850	1,440
Sulfur dioxide	160	310	530
Nitrogen oxide	2,000	1,720	2,910
Carbon monoxide	40,800	470	790
Hydrocarbons	3,550	1,050	1,780
Tire particulates	80	180	260

^aAdapted from CRC Press (1972).

^bAverage 10-ton.

Transportation associated with L-Reactor operation at the Savannah River Plant is expected to consist of cars and light trucks for 643,700 kilometers burning 147,600 liters of gasoline and trucks weighing less than 10 tons for 241,000 to 491,000 kilometers burning 64,400 liters of diesel fuel each year. This would consist of an incremental transportation increase of 8 percent for the total Savannah River Plant. Neither the increased onsite or offsite transportation pollutant sources are expected to significantly impact ambient air quality.

The potential for transportation accidents involving shipments of materials offsite is assumed to be comparable to that for general truck transportation in the United States. Based on accident rates and injury and fatality rates (AEC, 1972; Clarke et al., 1976), 0.4 injury and 0.02 fatality are expected annually from truck accidents associated with offsite shipments of L-Reactor materials.

The potential for transportation accidents onsite with resultant injury or fatality is much less than for public highways. Shipments onsite are almost never made during shift change and occur when traffic densities on the SRP highways are very low. Therefore, the risk of injury or fatality from operation of vehicles onsite is much less than one per year.

4.3.2 Radiological impacts

4.3.2.1 Routine radiation exposures

Onsite transportation

Nuclear materials moved onsite are packaged to contain the material during transit and shielded to minimize radiation exposures to drivers, riggers, and others near the material during transportation activities. The DOE contract permits the operating contractor to use procedural controls, escorts, and traffic controls to transport materials onsite.

The 70-ton railroad casks used to ship irradiated reactor fuel are separated from the locomotive by one or two spacer cars. The incremental exposure to the rail crew is estimated to be less than 10 millirem per year, based upon 1979 and 1980 exposure records.

The casks used to ship irradiated materials from reactor areas by truck are mounted on assigned trailers and do not require rigging. The annual radiation exposures, averaged over a 6-year period, were 330 millirem per year or less to the drivers who exclusively transport scrap metal and deionizer casks from the three operating reactors. Radiation exposure records show that cumulative exposures to T&T employees average about 2 to 3 person-rem per year per reactor area for all rigging and transportation activities.

Offsite transportation

The radiation levels from offsite shipments on exclusive-use vehicles to or from SRP are well below DOT radiation limits for transportation of nuclear materials. Typical measured radiation levels from these shipments are (1) depleted uranium shapes - less than 1 percent of DOT radiation limits, (2) uranyl nitrate

uranium shapes - less than 1 percent of DOT radiation limits, (2) uranyl nitrate solutions in MC 311 cargo tanker - less than 2 percent of DOT radiation limits, and (3) safe secure transporter (SST) - about 10 percent of DOT radiation limits.

The radiological exposure from transportation of these nuclear materials from and to SRP is small, about 0.01 person-rem per year to the population along the shipping route; this subject was addressed in the NRC report, Final Environmental Statement on the Transportation of Radioactivity by Air and Other Modes (NRC, 1977a). Therefore, the consequences will not be examined in detail in this study.

4.3.2.2 Safeguards

TC | Enriched uranium and plutonium resulting from L-Area operation would be shipped to and from Savannah River Plant in packages that meet the DOT Type A₂ requirements. These shipments would be safeguarded in the DOE's existing SST system with a courier escort. This transporter is essentially a mobile vault with built-in deterrent and disabling devices and special electronically coded locks set in vault-type doors; it is operated by carefully selected, specially trained personnel.

MC 311 or MC 312 cargo tankers are used to transport enriched uranyl nitrate hexahydrate solution. They are moved with SST tractors with a DOE escort.

4.3.2.3 Accident release risks

The cumulative risks from accidents during onsite transportation activities (in curies per year) for a single reactor are estimated to be about 2×10^{-3} curie beta-gamma per year, 2×10^{-5} curie alpha per year, and 3×10^{-2} curie tritium per year, as shown in Table 4-27. The radiological risks expressed as ~~curie-per-year-values-were-calculated-using-the~~ GASPAR code defined in NRC Regulatory Guide 1.109 (NRC, 1977b), as modified for accidental releases.

The calculated total-body radiological risk to the offsite population from accidental release of nuclear materials in transport to and from L-Area operation would be 1.1 person-rem per year and, to the maximally exposed member of the population, would be 0.017 millirem per year (Table 4-28).

In the NRC analysis of radiological risks from radionuclide transport, several serious accidents were postulated and the release of radioactive material was assumed. However, the consequences of most events were determined to be not severe. The most serious postulated accident results in one early fatality and exposure of 60 persons to significant levels of radiation. The probability of such an event was estimated to be less than 3×10^{-9} per year for shipping rates in 1975 and is expected to decrease further due to more stringent shipping requirements that have been initiated or are planned (NRC, 1977a). Uranyl hexahydrate solution is shipped in DOT MC-311 or MC-312 cargo tanks that might, after an accident, release uranyl nitrate solution on or near a bridge and could contaminate a stream supplying a public water supply. In an extreme

Table 4-27. Annual onsite risk during transportation for L-Area

Shipping operation	Risk (Ci/yr) ^a		
	Beta-gamma	Alpha	Tritium
Irradiated fuel	1×10^{-6}	1×10^{-9}	2×10^{-4}
Unirradiated fuel		Very small	
100-Area sample trucks	--	--	2×10^{-2}
Scrap metal		Extremely small	
Solid wastes	$<1 \times 10^{-6}$	$<1 \times 10^{-9}$	
Moderator shipments	--	--	3×10^{-3}
Unshielded trailer shipments	2×10^{-3}	2×10^{-5}	
Deionizers			
Reactor basin	1×10^{-6}	1×10^{-9}	
Purification		Very small	
Total	2×10^{-3}	2×10^{-5}	$<3 \times 10^{-2}$

^aAdapted from Du Pont (1982b).

Table 4-28. Annual radiological risk to the public from potential transportation accidents

Dose commitment	Risk	
	Maximum individual (mrem)	Population (person-rem)
Total body	1.66×10^{-2}	1.12
Bone	5.31×10^{-1}	3.55×10^1
Lung	5.29×10^{-2}	2.68
Liver	6.07×10^{-2}	3.96
Thyroid	8.29×10^{-5}	9.52×10^{-3}
Kidney	4.61×10^{-2}	3.01
GI-tract	7.33×10^{-4}	4.93×10^{-2}

accident scenario involving a major fire, some respirable particulates might be generated. The integrated radiological risk to the population along the route from these scenarios is about 2×10^{-6} person-rem per shipment.

4.4 L-REACTOR MITIGATION ALTERNATIVES

This section includes evaluations of the following mitigation alternatives: safety-system alternatives, cooling-water alternatives, and alternatives for the

disposal of liquid waste and 186-Basin sludge. This section describes the effects of the possible implementation of each of these alternatives and its mitigation costs and schedules.

4.4.1 Safety-system alternatives

In part because of their low-temperature, low-pressure operation, SRP reactors have a low potential for an accidental widespread dispersion of radioactivity. Also, SRP reactors are equipped with instrumentation, computer controls, supplementary shutdown systems, and multiple cooling systems that provide a high degree of safety assurance against accidents that might cause fuel melting and releases of radionuclides to the environment. The following systems are being considered to mitigate potential accident consequences:

- Remote storage system
- Low-temperature adsorption system
- Tall stack
- Internal containment system
- Leaktight dome

After a brief description of each system the systems are compared using the following measures:

1. Technical feasibility
2. Capital cost
3. Cost of lost production
4. Total cost
5. Benefit in extra person-rem averted beyond existing confinement system performance
6. Cost/benefit ratio in dollars per extra person-rem averted, assuming an accident occurs
7. Timing

4.4.1.1 Existing confinement system (preferred alternative)

SRP reactors were built in the early 1950s, before containment systems became an accepted practice for nuclear reactors. In the 1960s, a variety of containment/confinement systems were considered for SRP reactors; the vented confinement system was selected as the optimum balance between cost and risk. The cost of a containment vessel over the large, sprawling SRP reactor buildings is considered to be impractical compared to the risk associated with improbable reactor accidents.

SRP reactors are designed and operated to make the melting of fuel or target material, with the consequent release of radioactivity to the environment, highly improbable. Nevertheless, these reactors are equipped with a confinement system, which consists of a series of filters through which air is exhausted from the reactor building. This system traps moisture and particulates and absorbs radioactive iodine on carbon filters. Noble gases and tritium would pass through the system and would be exhausted to the atmosphere from a 61-meter stack.

The confinement systems for the SRP reactors are not subject to overpressurization because the system is vented through filters and a stack. Furthermore, these reactors operate at a coolant temperature and pressure much lower than a commercial power reactor. The "stored energy" within an operating SRP reactor is much less than that within an operating power reactor; therefore, the risk of overpressurization is much less.

Calculated offsite doses for average meteorology with this system do not exceed 0.39 rem to the whole body and 1.5 rem to the thyroid of the individual receiving the maximum exposure for the range of postulated accidents. |TC

4.4.1.2 Remote storage system

Among several possible improvements to the confinement system is a remote storage system, as illustrated in Figure 4-13. In this system the reactor room exhaust is separated from other reactor-building exhausts and fed through a large online storage tank, as shown in Figure 4-13. Nearly 1 hour of normal reactor room exhaust flow could be contained in the long storage tank. One hour after an accident, the storage tank would be isolated so that the initial release of radioactive material would be trapped. Any further effluent from the reactor room would bypass the storage tank. Downstream of the storage tank, the reactor room exhaust flow joins flow from the purification and below-grade areas, such that all building exhaust flow (except from assembly and disassembly) passes through a large sand filter and underground carbon filters. Thus, releases of noble gases and tritium occurring during the first hour would be retained and radioactive iodine and airborne particulates would be captured regardless of the source or duration of the accident. |TC

Exhaust from either purification (e.g., blanket gas-venting) or below-grade areas (e.g., heavy-water spills) can be procedurally diverted into the storage tank (see Figure 4-13) to improve control of other minor incidents. A 300-meter stack would help mitigate the consequences of a possible upstream failure to contain the release. It is included as a part of this alternative.

4.4.1.3 Low-temperature adsorption system

Another possible improvement to the confinement system is a low-temperature solid-adsorption system using hydrogen mordenite as a noble gas adsorbent in addition to more conventional filters. Laboratory experiments have been conducted and a concept has been proposed for this multipurpose system. However, this concept would require much more development work before engineering feasibility

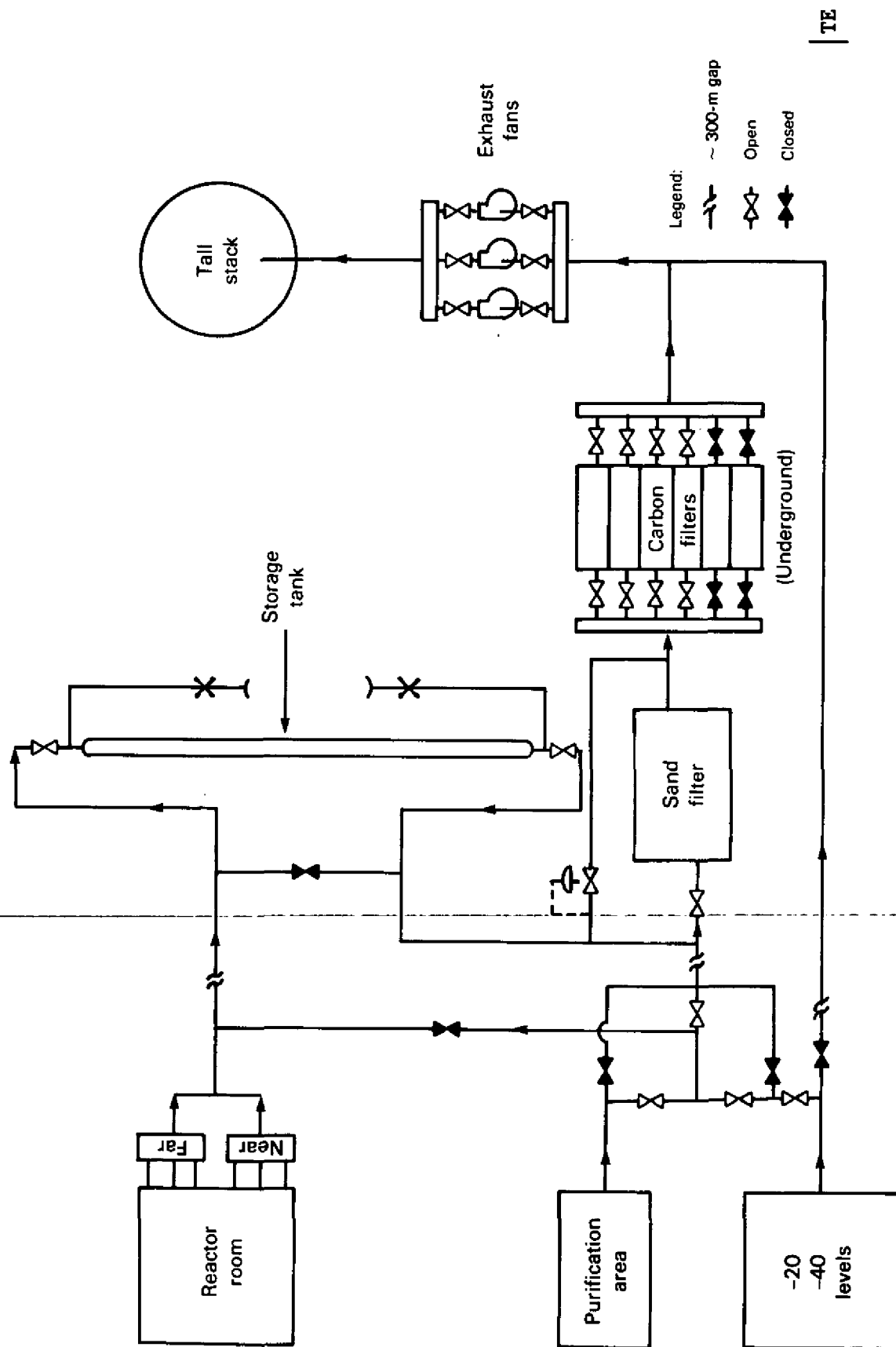


Figure 4-13. Remote storage confinement system.

could be demonstrated. This system is schematically illustrated in Figure 4-14. The reactor-room air flow is separated from other process area exhaust flow. During normal operation, all of the exhaust air from the reactor room and the process areas passes through the filter compartments just as it does with the existing confinement system. Immediately following an accident the reactor room exhaust flow would be diverted through a separate filter train powered by a new 8500-cubic-meter-per-hour fan before it entered the normal operation filters. The noble gas adsorption train would have to be designed compact enough to be placed within the reactor room. The diverted reactor room exhaust air would first pass through a hydrogen recombiner, a high efficiency particulate filter, and a special iodine trap. The bulk moisture and tritium would then be removed in a combination chiller/molecular sieve trap before the air passes through multiple low-temperature (-40 to -60°C) adsorption beds of hydrogen mordenite. This system is expected to remove about 99 percent of the noble gases and tritium released in addition to providing much better iodine retention.

4.4.1.4 Tall stacks

Tall stacks for the reactor exhaust have been considered as a means of increasing the dispersion of reactor effluents. They can provide an appreciable reduction in exposure to the maximum individual onsite doses near the reactor and reduce site boundary doses. However, the tall stack concept does not reduce population dose as well as the other concepts.

4.4.1.5 Containment system

Commercial power reactors in the United States are built in large cylindrical buildings, which serve as containment vessels. They usually are built of heavy reinforced concrete with steel liners that are relatively leak-tight under moderate pressure. Such a containment is designed to withstand the pressure (about 0.34 megapascal) that would result if the reactor piping system suddenly burst and released the reactor coolant (steam and water at about 15.2 megapascals of pressure and 293°C) to the reactor building. The containment would retain most of the fission products, even in this improbable situation. A small amount of leakage of fission products from the containment system is permitted and has been accepted by NRC as having extremely small impacts.

The following paragraphs describe two variations of a containment system for SRP reactors.

Internal containment structure

In this concept, a leaktight containment zone would be created inside the existing building. A leakage rate below 1.7 cubic meters per hour might be achieved with this system, but continued maintenance to achieve this standard would be very difficult.

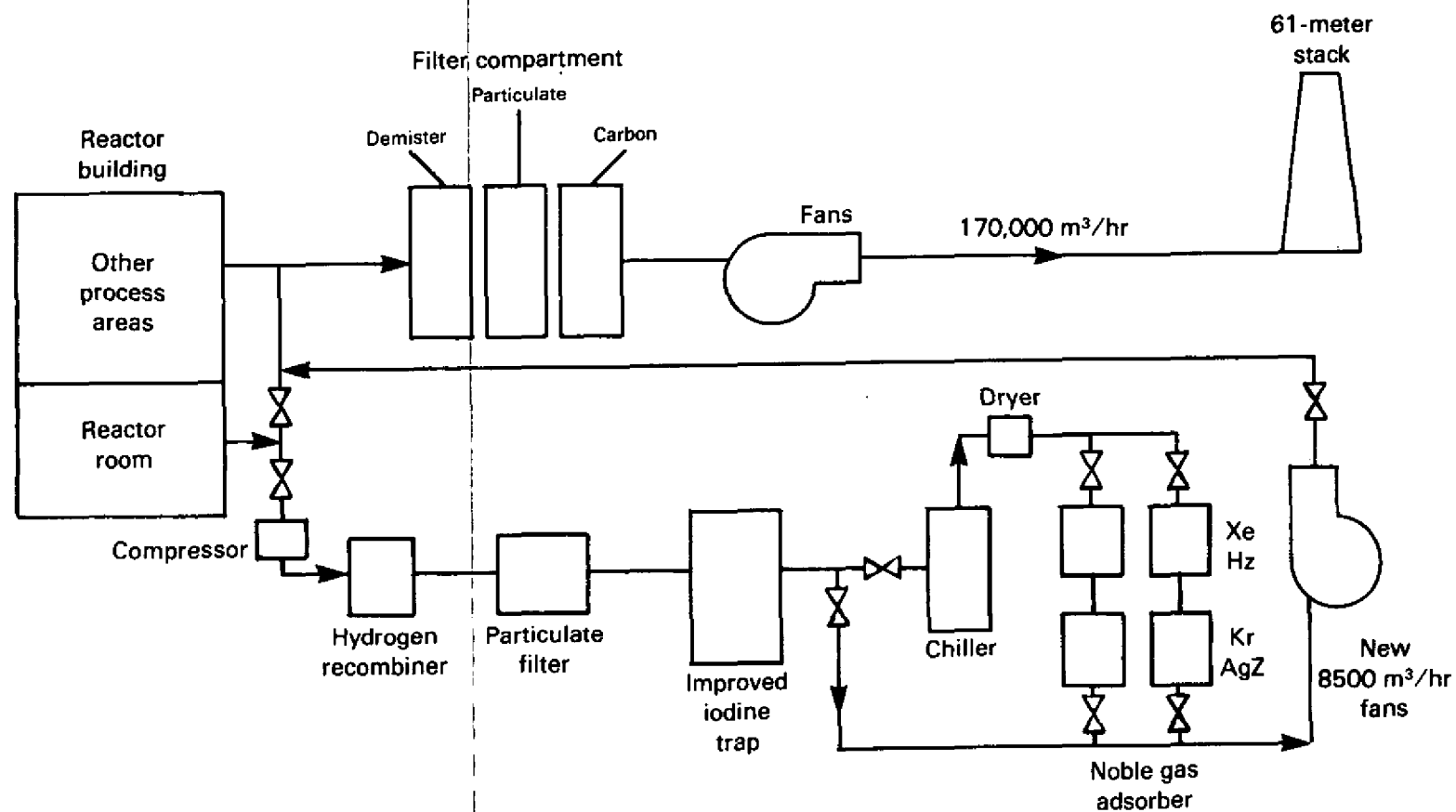


Figure 4-14. Low-temperature adsorption system.

The internal containment zone would consist primarily of the actuator tower, the reactor process room (extended out to include the charge and discharge machine service area and up to enclose the shield door gantry), the heat exchanger bay (beyond the cooling-water headers), and the main pump rooms. The entire containment zone would be lined with steel plate (Figures 4-15 and 4-16) backed by several concrete floor and wall thicknesses. Penetrations would be seal-welded in most cases and nonshrink grout would be used to seal the inside of conduits and cable trays. Special closures would be installed for the discharge and exit canal, presentation point, corridors, personnel doors, pump shaft penetrations, etc.

A heat-removal system would be provided to prevent pressurization from the heat released after a meltdown accident. A deluge spray system would cool the open volume inside the containment zone. After use of the initial supply of water from the disassembly basin and the 186-Basin, the water would be recycled from the -40 floor through a heat exchanger and back through the spray nozzles.

A new recirculating ventilation system would also be needed for the containment zone. This system would always be online except for purging during shutdowns. The existing once-through ventilation system (throttled appropriately) would serve the reactor building outside the containment zone. During normal operation, 10-percent outside makeup air would be admitted into the actuator tower and the crane service area to keep these areas accessible.

External containment structure

Another containment concept for the SRP reactors would be a leaktight dome structure over the entire reactor building complex (the stack would protrude). While theoretically possible, such a massive dome would be, at best, a formidable engineering challenge.

The dome itself would be a concrete structure semi-ellipsoidal in shape approximately 183 meters in diameter at the base and 61 meters high. The concrete would be lined with welded steel plating to achieve leaktightness (less than 0.1 percent leakage of the enclosed volume per day). The below-grade areas would also have to be sealed with steel plate to achieve the same standard of leaktightness. Extensive modifications to the existing ventilation system would be required to supply the new dome and to isolate and recirculate air inside the dome following an accident.

4.4.1.6 Comparison of alternatives

Table 4-29 provides the various measures of comparison outlined above for the alternative safety systems described. The existing confinement is the preferred alternative. The cost-benefit ratios per person-rem averted all appear extremely high for any of the alternatives compared to the present confinement system, particularly when the benefit includes the probability of the hypothesized accident occurring. By comparison, EPA (1976) has recognized a range from \$250,000 to \$500,000 per health effect averted as reasonable. (This range corresponds to a range from \$30 to \$60 per person-rem averted based on BEIR III estimates of cancer fatalities.) NRC has assigned a different (and larger) value of \$1000 per person-rem as a basis for estimating the need for additional

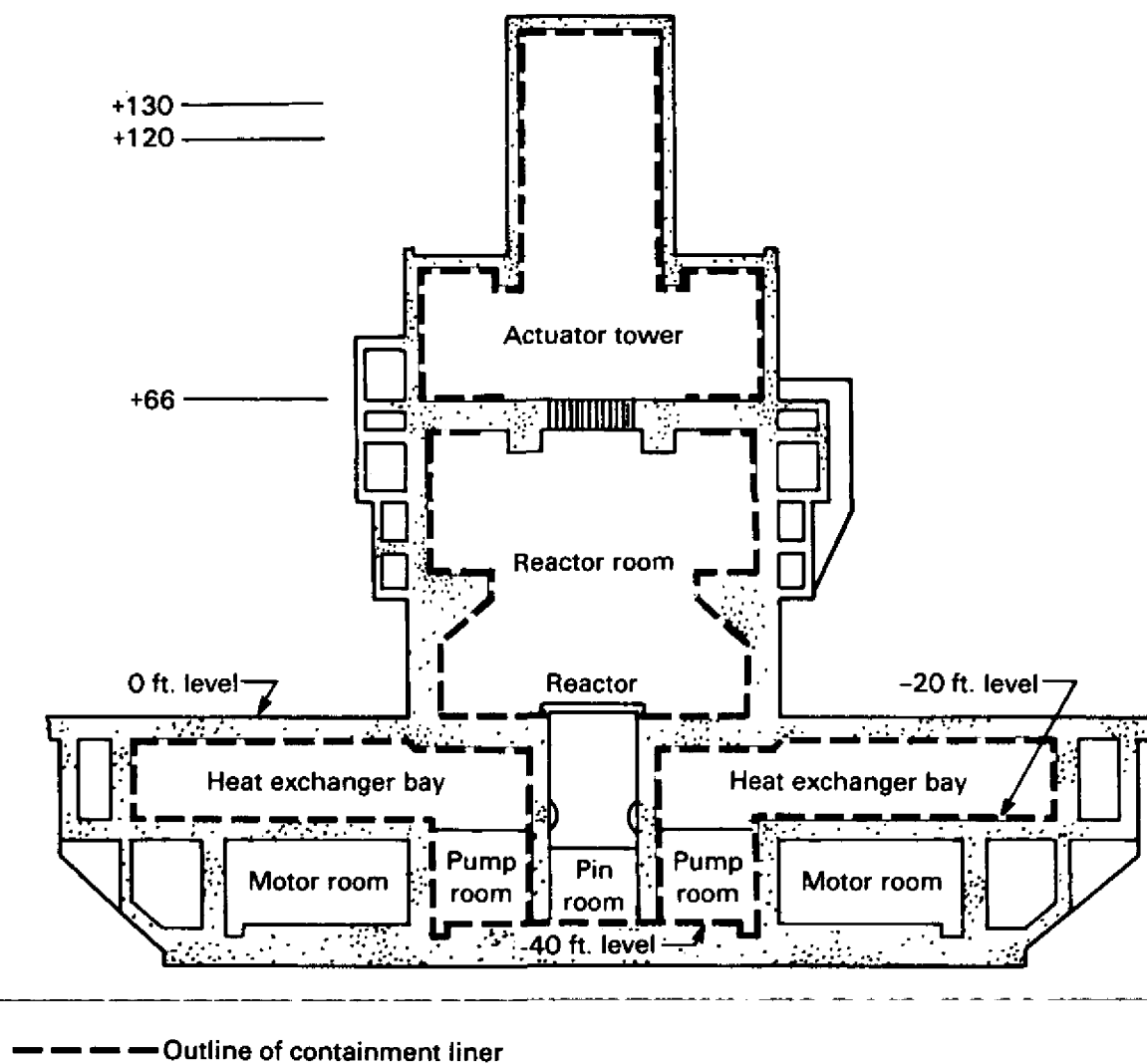


Figure 4-15. Vertical outline of containment liner, view 1.

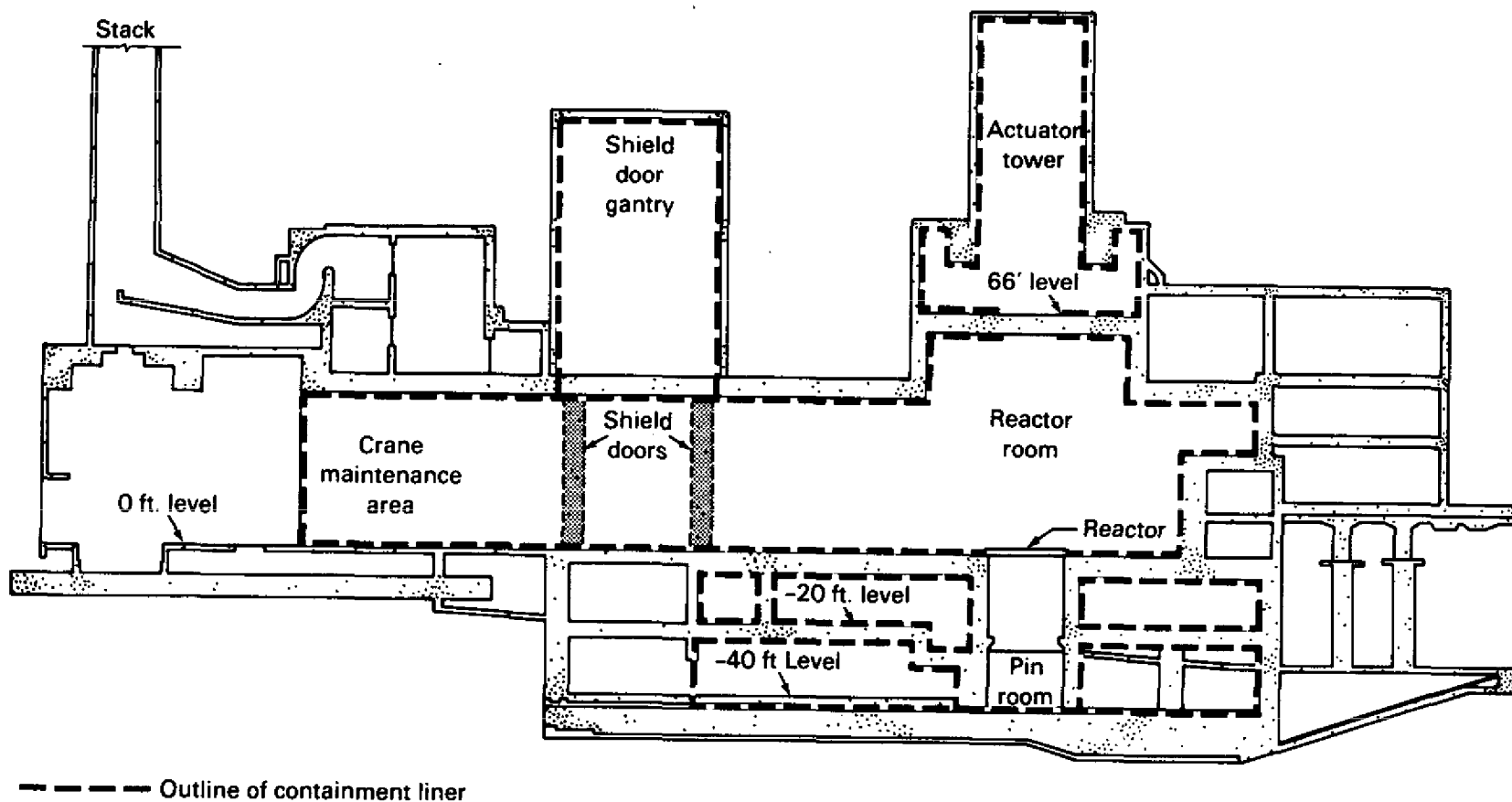


Figure 4-16. Vertical outline of containment liner, view 2.

Table 4-29. Comparison of safety system alternatives (primarily confinement/containment options)

System	Technical feasibility	Estimated costs (\$MM) ^a			Benefit person-rem averted ^d (3% melt)	Cost/benefit ^e (\$ per person-rem averted)	Timing (months to complete)
		Capital ^b	Production Loss ^c	Total			
Existing confinement (ref) system	Demonstrated and proven	Installed	None	Installed	--	Reference	Installed
Remote storage system	Demonstrated	250	25	275	445	620,000	24
Low temperature adsorption system	Not demonstrated	90	50	140	460	300,000	36
Tall stack	Demonstrated	50	15	65	175	370,000	15
Internal containment	Questionable	250	150	400	455	880,000	48
Leaktight dome	Questionable	850	50	900	450	2,000,000	36

^aMM - millions of dollars.

^bRough estimates escalated to 3Q FY 1988 construction midpoint.

^cRough cost of production lost during construction at \$150,000 per reactor-day.

^dAssumes hypothetical accident (3-percent melt) occurs. Dose within 80-kilometer radius from reactor (2500 megawatts accident). 50 percent meteorology. Benefit = (dose with existing confinement system - dose with alternative system) = person-rem averted.

^eThe expected cost benefit considering the probability of the accident is at least two million times greater than the values listed here.

equipment to reduce public exposures from radioactivity in effluents from nuclear power plants (10 CFR 50, Appendix I).

4.4.2 Cooling-water alternatives*

4.4.2.1 Introduction

The L-Reactor secondary coolant system would withdraw water from the Savannah River. This water would be pumped from the river through pipelines into the 95-million-liter 186-L cooling-water reservoir. From there it would flow through heat exchangers that transfer heat from the heavy-water primary coolant to the secondary cooling water. Under the reference case (direct discharge to Steel Creek), the heated river water would leave L-Reactor at a rate of about 11 cubic meters per second and at temperatures as high as 73°C; it would flow from the discharge canal into Steel Creek and then into the Savannah River.

The preferred cooling-water alternative of the Department of Energy is to construct a 1000-acre lake before L-Reactor resumes operation, to redesign the reactor outfall, and to operate L-Reactor in a way that assures a balanced biological community in the lake (i.e., to maintain 32.2°C or less for about 50 percent of the lake). The impacts of the 1000-acre cooling lake were bracketed in the Draft EIS by the 500-acre and 1300-acre cooling lakes. After L-Reactor is operating, DOE will conduct studies to determine the effectiveness of the cooling lake and to decide on the need for precooling devices to allow for greater operational flexibility. The preferred cooling-water alternative is discussed in detail in Appendix L.

This section describes possible thermal mitigation measures that could be implemented either before or after the restart of L-Reactor and their projected environmental effects, and assesses them with respect to meeting regulatory thermal criteria. Implementation of some of these alternative systems before direct discharge occurs would, to various degrees, reduce the environmental impacts to the Steel Creek system. If a cooling-water alternative is implemented after L-Reactor restart with direct discharge, the environmental impacts described in Section 4.1.1 would already have occurred. However, successional recovery of the Steel Creek system would begin after the mitigation alternative had been implemented. The extent of the successional recovery would depend on the thermal mitigation alternative implemented.

The evaluation of each alternative cooling system was based on its engineering feasibility, schedule, cost, L-Reactor production efficiency, and environmental effects. In general, the engineering costs presented in this section were based on limited design data. These costs can be used as a basis for a comparison of alternatives; however, they are not suitable for budgetary considerations. Schedules are based on normal construction work practices; some could be accelerated with increased costs. Estimates of construction personnel

*Because of the extensive revisions to this section, vertical change bars have not been used.

requirements are also presented. Actual construction personnel requirements can vary based on the final construction design and schedule considerations. Both once-through and recirculating cooling-water measures have been considered to reduce the environmental impacts of the heated discharge. Alternative cooling systems include the following four categories: (1) once-through alternatives, including direct discharge (reference case); (2) cooling towers (including once-through, recirculation, and partial recirculation); (3) recirculation alternatives using lakes; and (4) other mitigation alternatives.

Steel Creek flows southwesterly from its headwaters near P-Area to the Savannah River swamp, where it is joined by flows from Pen Branch and Four Mile Creek. A delta has formed where Steel Creek adjoins the Savannah River swamp. After flowing through the swamp, Steel Creek discharges into the Savannah River. The length of Steel Creek from the L-Reactor outfall to the delta is about 11 kilometers. The distance from the delta to the confluence with the Savannah River is about 2 kilometers.

The average flow rate of Steel Creek is about 0.6 cubic meter per second at Road B; this includes natural flow (0.17 cubic meter per second) and some non-heated process water from P-Reactor (0.45 cubic meter per second) (Section 3.4.1.2). Table 4-30 lists ambient temperatures calculated for selected points along Steel Creek. Figure 4-17 shows monthly average ambient temperatures in Steel Creek at the L-Reactor outfall (calculated), at Road A (measured), and at the mouth of Steel Creek (calculated). Table 4-8 (Section 4.1.1.5) summarizes the water quality data for Steel Creek.

Table 4-30. Calculated ambient temperatures (°C) for selected locations along Steel Creek during summer, spring, and winter

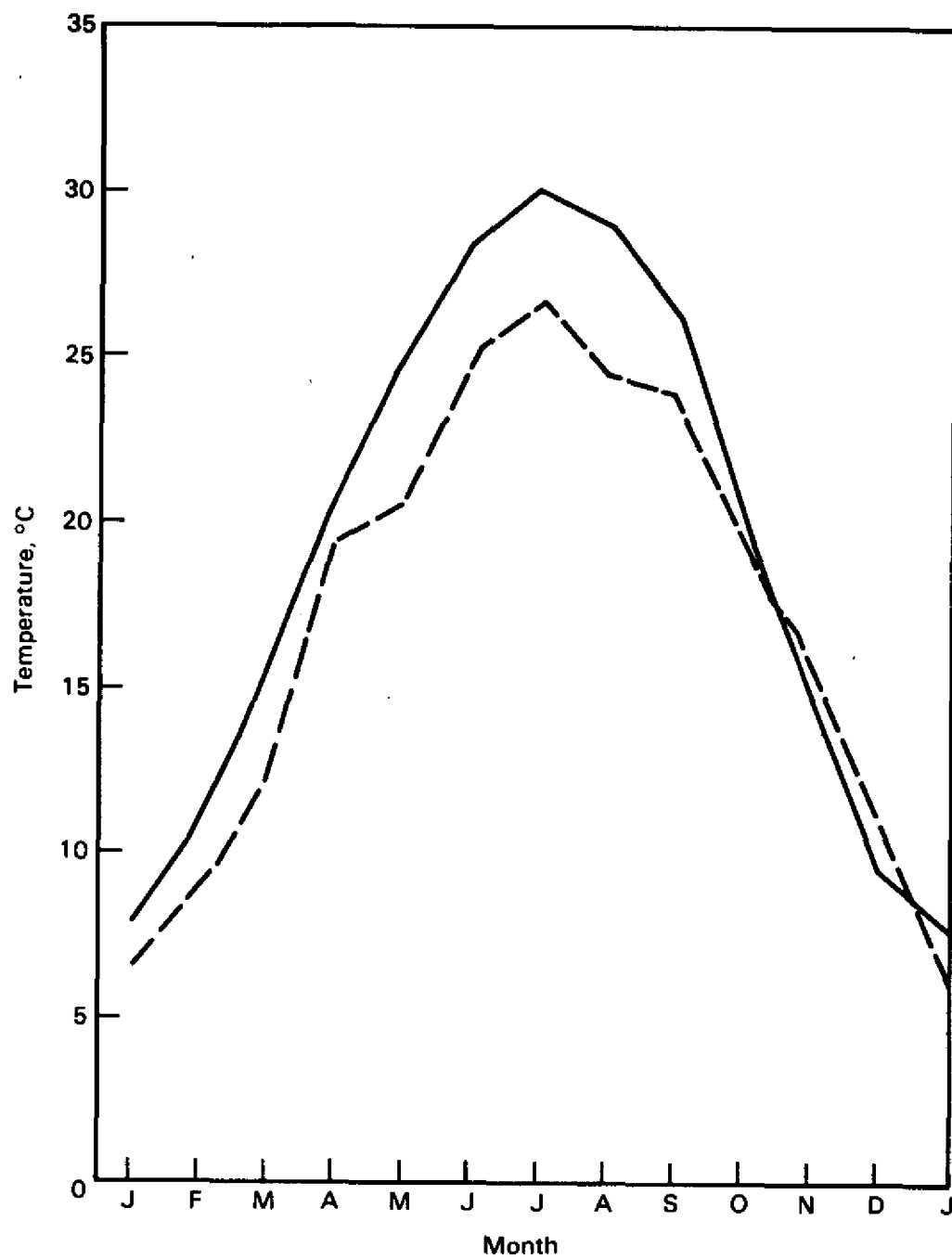
Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Near L-Reactor	33	29	22	8
Road A	33	29	22	8
Swamp at delta	33	29	22	8
Mid-swamp	29	26	19	6
Mouth of creek at river	30 ^c	27 ^c	21 ^c	12 ^c

^aBased on worst 5-day meteorological conditions (July 11-15, 1980).

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor.

^cTemperature increase due to mixing with K-Reactor effluent.

Predicted water temperatures are based on monthly average winter, spring, and summer meteorological conditions from 1953 to 1982; the extreme summer meteorological conditions are based on the most severe 5-day period from 1976 to 1980 (July 11 to 15, 1980). Five-day, worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered representative of extreme temperatures for which the maintenance of a



Legend:

- Steel Creek at outfall from L-Reactor; calculated temperatures.
- - - Steel Creek at Road A, 10-year average of one temperature measurement per month.

Figure 4-17. Monthly average ambient temperatures of Steel Creek.

balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act of 1972. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

Several of the cooling-water alternatives described in the following sections would require borrow pits or spoils piles, and could cause siltation. Borrow pits of suitable materials and similar quantities have been used in the past at the Savannah River Plant. For the alternatives described in the sections that follow, the most economically suitable pit would be identified and reclaimed.

Spoil piles of the size expected have also been developed for past construction activities at the Savannah River Plant and have met the necessary environmental control requirements. In this particular instance, spoil from any excavation in the former floodplain of Steel Creek would be monitored for radioactive species and would be disposed of in a suitable manner if such activity is found to be necessary.

Siltation would be controlled during all phases of construction.

Chapter 7 presents Federal and State environmental requirements applicable to the resumption of L-Reactor operation. These requirements emphasize air quality, water quality (including thermal discharge limits), the disposal of solid and hazardous wastes, the protection of fish and wildlife, and the preservation of cultural resources.

Appendix I describes floodplain and wetlands impacts associated with each alternative.

In recognition of the requirements for the discharge of dredged or fill material related to the potential construction of certain cooling alternatives discussed in this section, each alternative description contains information, as appropriate, on effects of such discharges pursuant to Section 404 of the Clean Water Act of 1977 and EPA regulations (40 CFR 230).

4.4.2.2 Once-through alternatives

Eleven alternative cooling systems that would receive direct discharge for L-Reactor have been evaluated. These include (1) the reference case (direct discharge), (2) a spray canal, (3) small lakes without sprays and with one or two sets of sprays, (4) a 500-acre lake without sprays and with one or two sets of sprays, and (5) a 1000-acre lake without sprays. Each would discharge heated effluent into Steel Creek at a rate of about 11 cubic meters per second. Two other alternatives would divert the discharge effluent into Pen Branch at about the same temperature and flow rate. The following sections describe and evaluate the environmental consequences of these various alternative cooling systems.

For once-through alternatives that require the use of a cooling lake, DOE will perform safety analyses for the design of the embankment to assure its stability during construction, closure, filling, drawdown, and under all conditions of lake operation, including appropriate earthquake loading. The design

will also assure that the embankment is safe against overtopping during the inflow of the design flood and during wave action. The purpose of these analyses will be to assure public safety, because a failure of the cooling-lake embankment could have adverse impacts on portions of the Seaboard Coast Line Railroad and South Carolina Highway 125 (SRC Road A) where they cross Steel Creek or other onsite streams below a cooling lake.

Impounded water for a cooling lake would cause a local ground-water mound in the water-table aquifer. This effect would dissipate with depth and is expected to have only a small effect on water levels in the McBean Formation. The green clay is an important confining unit separating the McBean from the underlying Congaree Formation. It would prevent the increased head associated with a cooling lake from impacting the head differential between the Tuscaloosa and Congaree Formations (see Figure 3-9). It is also an important barrier to the migration of contaminants from near the surface to lower hydrostratigraphic units. In the Separation Areas, the green clay (about 2 meters thick) supports a head difference of about 24 meters between the McBean and Congaree Formations. Based on water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin, the green clay has effectively protected the Congaree ground water from contamination seeping into the ground (Marine, 1965). In the L-Area, the green clay is about 7 meters thick. At the Par Pond pump-house along the strike of the McBean and Congaree Formations, the green clay also supports a large head difference; the water pumped from the Congaree Formation shows no evidence of tritium contamination, even though tritium concentrations in that lake were measured at 27,000 picocuries per liter. Water pumped from the Congaree by the pumphouse well exhibited tritium concentrations of 170 picocuries per liter or less in comparison to concentrations of 260 ± 60 picocuries per liter in offsite well water (Ashley and Zeigler, 1981).

4.4.2.2.1 Direct discharge to Steel Creek (reference case)

During direct discharge, heated cooling water would enter Steel Creek at the end of the existing outfall canal (as shown on Figure 4-18); the water would cool gradually as it flows to the river through the lower reaches of Steel Creek and the Savannah River swamp (Figure 4-19). No construction would be required. Because reactor discharge and associated impacts would be similar to those that occurred during previous L-Reactor operation, this alternative is called the "reference case."

The reference case would require no new structures, equipment, or capital costs. The present worth (based on a discount rate of 10 percent and operating cost for a period of 20 years) would be \$29 million, and the annualized cost (for this alternative, the same as the operating cost) would be \$3.4 million. Operating costs would be associated primarily with pumping the secondary cooling water from the Savannah River to the 186-L basin and with pumping water through the reactor heat exchangers (Du Pont, 1983d).

This alternative would use about 11 cubic meters per second of water from the Savannah River. Water would be discharged at a rate of 10.9 cubic meters per second (minor evaporative losses). Direct discharge is the only option available that would allow L-Reactor operation to begin in 1984. As the reference case, it has a 100-percent production efficiency.

The temperature of the water discharge would vary by month; it would depend on the temperature of the supply water from the Savannah River and on the

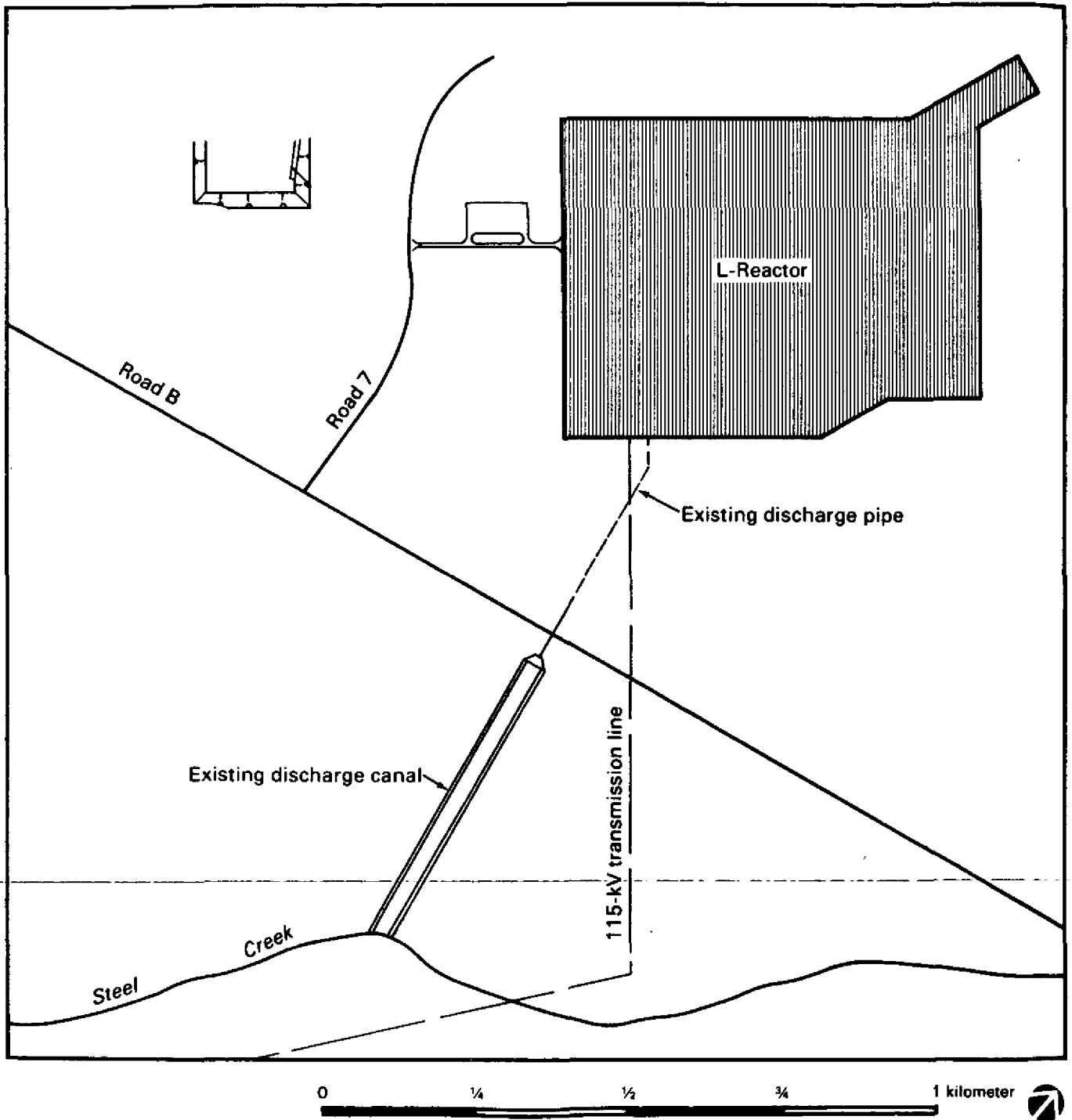


Figure 4-18. Direct discharge to Steel Creek at outfall.

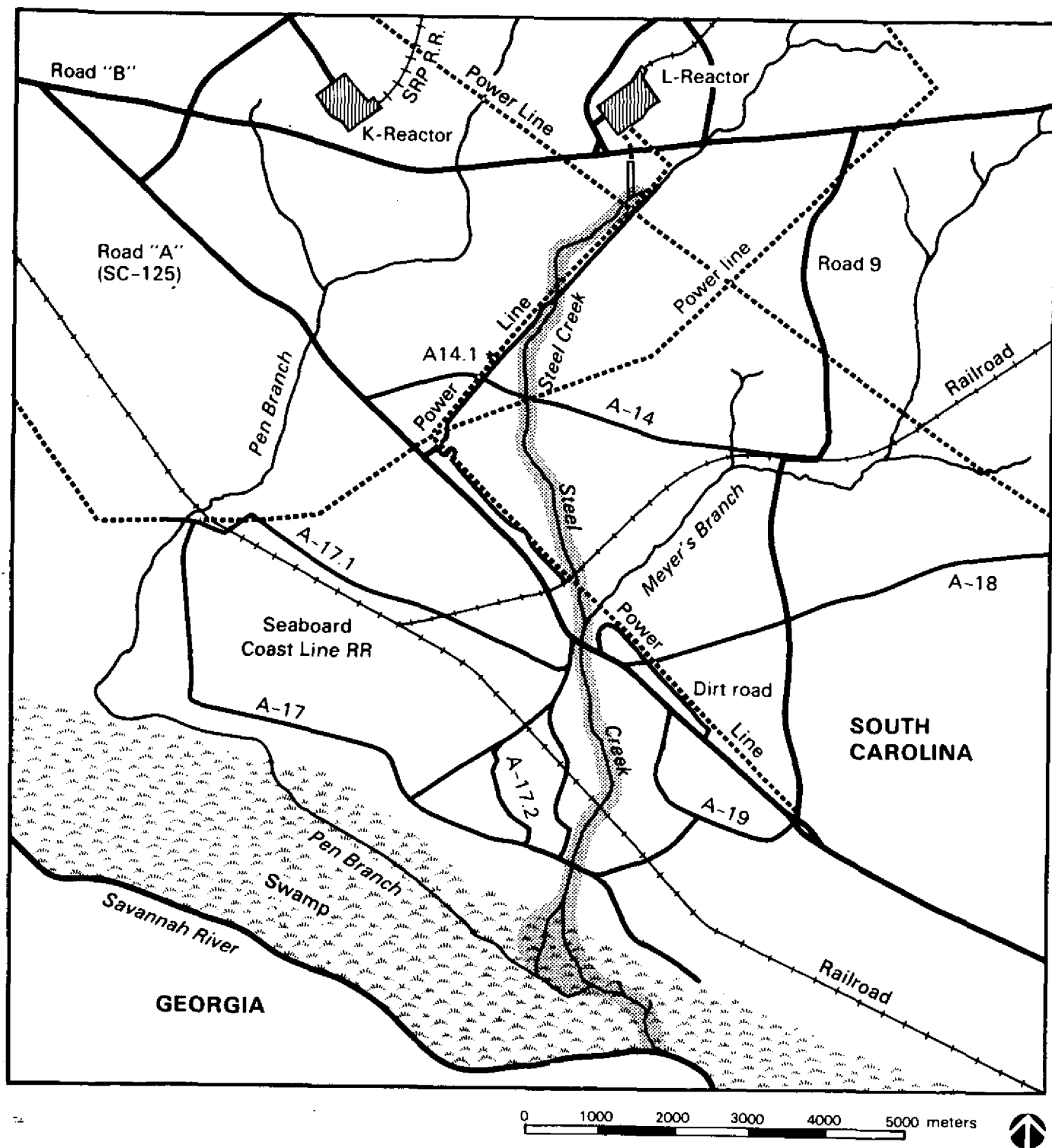


Figure 4-19. Steel Creek, showing area affected by direct discharge.

operating power of the reactor. The operating power would vary with the temperature of the water used for cooling. Figure 4-20 shows the estimated downstream temperatures in Steel Creek in the spring, summer, and winter. Table 4-31 lists downstream temperatures for this alternative.

Table 4-31. Temperatures (°C) downstream in Steel Creek with direct discharge

Location	Summera ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	73 ^d	71	69	66
Road A	54	53	50	46
Swamp at delta	46	45	41	36
Mid-swamp	37	35	31	25
Mouth of creek at river	34	33	28	21

^aBased on worst 5-day meteorological conditions (July 11-13, 1980) and estimated operating power of reactor. Five-day worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered to be representative of extreme temperatures for which the maintenance of a balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act of 1972.

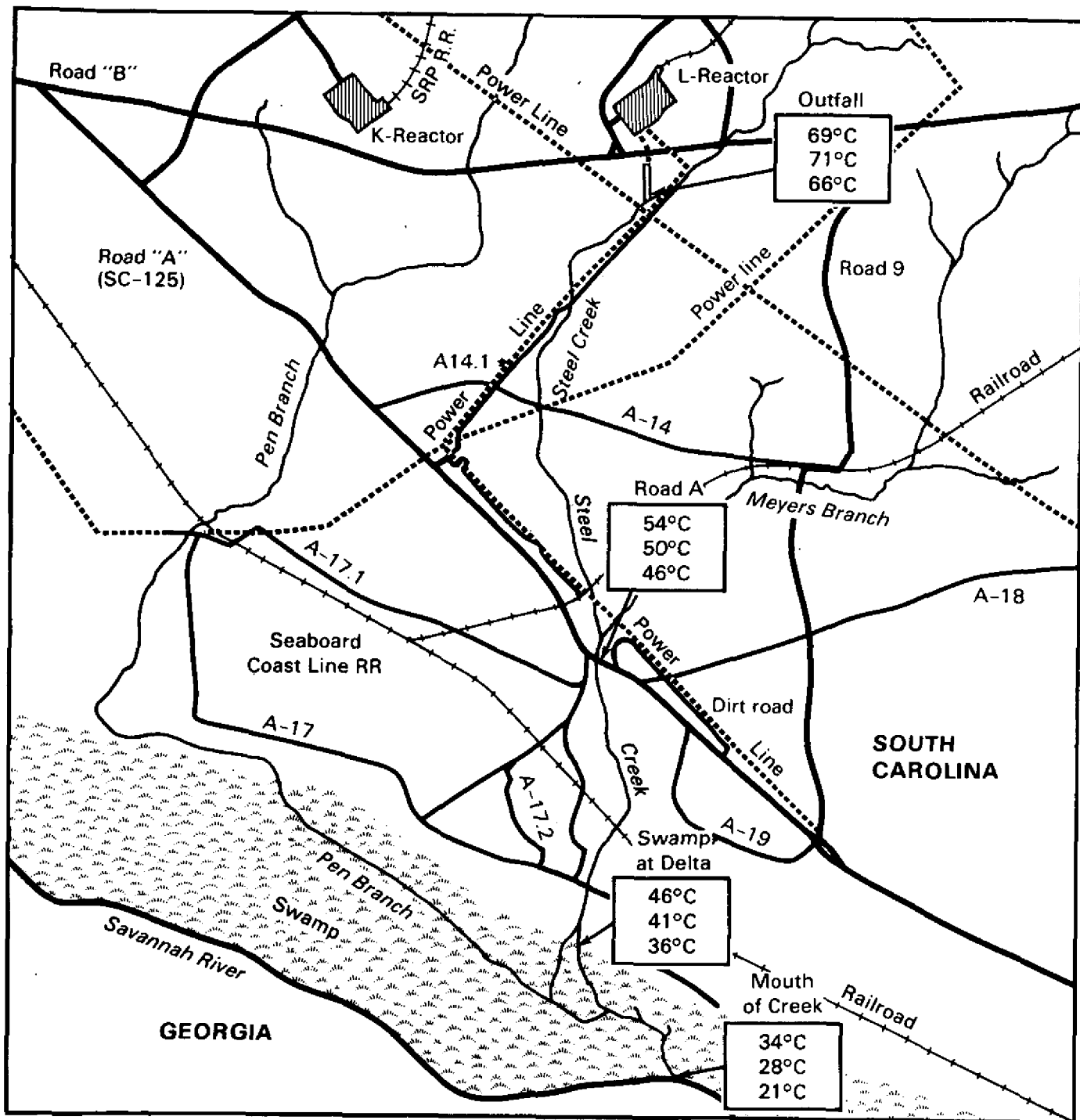
^bBased on 30-year average values for meteorological conditions and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cThe temperature of the water entering Steel Creek.

^dThe secondary cooling-water discharge temperature during extreme summer meteorological conditions has been reduced to 73°C. This reduced discharge temperature reflects reduced reactor operating power to compensate for increased temperatures in the cooling-water supply drawn from the Savannah River during the warmest summer months.

Direct discharge would not provide thermal mitigation. The 73°C maximum discharge temperature from this alternative would be well above the 32.2°C discharge limit promulgated by the State of South Carolina. Because of the high discharge flow rates, Steel Creek temperatures would approach the cooling-water discharge temperature near the outfall. This alternative would result in year-round noncompliance with State discharge limits in Steel Creek, but could be in compliance in the Savannah River when a mixing zone is considered.

Initially, direct discharge will eliminate about 730 acres of wetlands in the Steel Creek corridor, the Steel Creek delta, and the Savannah River swamp. These wetlands, which have become established during the past 15 years through the process of natural succession, are structurally different from the closed



Legend:



Swamp



Seasonal creek temperatures
for this alternative

0 1000 2000 3000 4000 5000 meters



Figure 4-20. Steel Creek seasonal temperatures for direct discharge.

canopy of mature cypress and tupelo gum that existed before the SRP began operations (Sharitz, Irwin, and Christy, 1974). Furthermore, these wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOl, 1981). The vegetation of the corridor, which extends from the L-Reactor outfall to the delta, consists primarily of forested (73 percent) and scrub-shrub (24 percent) wetlands. The dominant flora of the forested wetland is alder, wax myrtle, and willow. Alder dominates the scrub-shrub wetland. Between 310 and 420 acres of the Steel Creek delta, which is dominated by forested (45 percent) and scrub-shrub (36 percent) wetland, would also be eliminated; this includes feeding and roosting habitat for 1200 mallards and 400 wood ducks.

Fish and other food sources would no longer inhabit the impacted Steel Creek or the delta-swamp area. Although 2280 acres of the wetlands along Steel Creek above L-Area and along Meyers Branch above its confluence with Steel Creek would not receive direct thermal discharges, access to these areas by fish from the Savannah River would be restricted. The entrance to Boggy Gut Creek, an offsite tributary immediately downriver of Steel Creek, could be blocked by the thermal plume at times and fish access would be limited. Wetland areas of Boggy Gut Creek total about 230 acres.

Thermal plumes in the Savannah River resulting from SRP operations (including L-Reactor), Vogtle Nuclear Power Plant (under construction), and the Urquhart Power Plant at Beech Island would not interact. A zone of passage for anadromous fish and other aquatic organisms would exist in the river near the Savannah River Plant.

The thermal plume in the Savannah River would increase the overall river temperature by less than 0.8°C about 2.4 kilometers downstream after total mixing; the calculated 1-week-in-10-year maximum increase resulting from SRP operations, including L-Reactor, would be 2.3° to 2.4°C. The expected thermal impacts of direct discharge in the river would be small, except near the mouth of Steel Creek, where temperatures could be high enough to exclude the creek and portions of the swamp as spawning areas for riverine and anadromous fish.

Before 1982, the endangered shortnose sturgeon had not been reported in the middle reaches of the Savannah River near the Savannah River Plant. In 1982, two shortnose sturgeon larvae were collected at River Mile 157.3, which is upstream from the IG pumphouse. In 1983, seven shortnose sturgeon larvae were collected, five in the Savannah River adjacent to SRP (two from the canal and three from the river). Two larvae were also collected at River Miles 79.9 and 97.5, both of which are more than 60 miles downriver from SRP. Thus, impingement or entrainment could cause some larval mortality (ECS, 1983b). DOE included these factors and other data in the biological assessment and consultation process with the National Marine Fisheries Service, which concurred that this alternative would have no adverse effects on the shortnose sturgeon (Oravetz, 1983).

An estimated 23 to 35 individuals of the endangered American alligator inhabit parts of Steel Creek from the L-Reactor outfall to the cypress-tupelo forest adjacent to the Steel Creek delta; they also use areas lateral to Steel Creek, including Carolina bays, backwater lagoons, and beaver ponds. This

species is described in greater detail in Section 4.1.1.4 and Appendix C. Direct discharge would eliminate feeding and breeding habitat in the Steel Creek corridor and portions of the swamp. The mobility of adult alligators should eliminate any mortality due to the direct impact of heated water. Juveniles would have greater difficulty avoiding thermal effluents, and would be exposed to greater predation. DOE included these factors and other data in the biological assessment and in continuing consultations with the U.S. Fish and Wildlife Service (Sires, 1983).

The wood stork is classified as threatened by the State of South Carolina, and as endangered by the U.S. Fish and Wildlife Service. A total of 478 observations was made in the Savannah River swamp in 1983, of which 102 were in the Steel Creek delta. Although roosting by the wood stork in the Steel Creek area is infrequent, the Steel Creek delta represents an important foraging site for breeding storks from the Birdsville rookery. This alternative would eliminate this foraging habitat. DOE will include these factors and other data in the biological assessment and consultation process with the U.S. Fish and Wildlife Service.

The fish egg and larvae entrainment produced by this alternative would result in 7.7×10^6 additional eggs and 11.9×10^6 additional larvae lost annually because of water requirements by L-Reactor. Based on 1982 and 1983 sampling data, these totals represent approximately 3 to 6 percent of the fish eggs and larvae in the Savannah River water passing the intake canal. This alternative would cause an estimated 16 additional fish per day to be impinged on the intake screens (5840 annually; average fish weight would be about 14 grams).

This alternative would remobilize and transport radiocesium from the Steel Creek system when cooling-water discharges resume. Approximately 4.4 ± 2.2 curies of radiocesium would be transported from the creek during the first year of resumed operations. Thereafter, radiocesium transport would decrease by an estimated 20 percent per year (Section D.4). Expected maximum concentrations in the Savannah River would average less than 0.5 picocurie per liter during average flow conditions. The Beaufort-Jasper County and Cherokee Hill (serving Port Wentworth, Georgia) water-treatment plants obtain their raw water from the Savannah River more than 100 river miles downstream from Steel Creek. Finished (potable) water from these plants is expected to contain no more than 0.09 picocurie of cesium-137 per liter, or 2200 times less than the EPA drinking-water standard (200 picocuries per liter).

In the tenth and subsequent years, L-Reactor would discharge about 14,600 curies of tritium each year to the environment via liquid effluent. About 75 percent of this total would be diverted to a low-level radioactive seepage basin; about 30 percent of the tritium discharged to the seepage basin is expected to evaporate. About 6000 curies per year would be discharged to Steel Creek via ground-water transport (assuming radioactive decay during the 4.4-year travel time to the outcrop, but neglecting dispersion effects). The remaining 25 percent (approximately 3600 curies per year) would be carried in the cooling water (Table 4-9).

Five archeological sites eligible for listing on the National Register would be subject to erosion and flooding from the implementation of this alternative. These include one prehistoric site and four historic sites. Cold water

testing has indicated that erosion is occurring. A mitigation plan of rip-rapping is being designed whereby these sites will be protected in accordance with the Archeological Mitigation Plan. This plan has been approved by the South Carolina State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (ACHP) (Lee, 1982). This mitigation is being designed by the Institute of Archeology and Anthropology of the University of South Carolina and will be completed prior to restart.

Steel Creek has received various reactor effluents since 1954, which have impacted its substrate accordingly. Increased flows that were sometimes an order of magnitude above normal altered the erosion-sedimentation patterns of the stream corridor (Smith et al., 1981). Upstream areas where stream gradients are high (7.8 meters per kilometer near L-Reactor) are severely eroded; downstream areas with low gradients (1.0 meter per kilometer near Cypress Bridge) receive sediments that drop from suspension as the water velocity decreases. Suspended solid loads in Steel Creek reached levels of 99 milligrams per liter during large rainfall storm events (Giesy and Briese, 1978) and declined from 80 milligrams per liter at Road A-14 to 14 milligrams per liter at the HP monitoring station at Cypress Bridge on Steel Creek during flows as high as 4 cubic meters per second in 1980.

This alternative would require no dredging and filling; thus, the substrate would not be affected by these activities. However, the combination of increased flow and temperatures would have adverse impacts on the substrate of Steel Creek. This substrate consists of Bibb sandy loam (Figure C-2); it is stabilized by macrophytic vegetation. The direct discharge of cooling-water effluent from L-Reactor would increase the flow rate at the outfall from about 0.6 (which includes the natural Steel Creek flow measured at Road B and some nonheated process water from P-Reactor) to about 11.4 cubic meters per second (1.36 for natural and P-Reactor discharges + 10.9 for L-Reactor cooling water - 0.85 consumptive use = 11.4) at Cypress Bridge, about 2.8 kilometers below Road A. The resulting erosion of upstream segments and the deposition downstream would alter the substrate elevation and contour of the Steel Creek corridor, scouring and burying vegetation. North of Road A, only vegetation rooted above the water level is expected to survive. The anticipated maximum delta growth rate at the swamp would be 3 surface acres per year from the deposition of sediments. No alteration of substrate elevation or contours of the Savannah River is expected.

In Steel Creek, reduced light penetration caused by turbidity from suspended particulates would lower the photosynthetic rates of those remaining thermotolerant and thermophilic algae, such as blue-greens. The reduction and elimination of submerged vegetation could create locally high oxygen demand due to decomposition.

Spawning and feeding success by the remaining fish species that move to avoid the heated effluent would be reduced due to siltation by suspended particulates from the initial restart of the reactor. This impact is expected to decrease as the turbidity decreases and sediments become more stable. As the effluent moves away from the reactor outfall and flow velocities decrease, turbidity would decline and more organisms would occur, beginning with those most tolerant to siltation effects. The expected total suspended and dissolved solid

concentrations at Road A would be much less than the water-quality/drinking-water standard (Table 4-6). As discussed in Section 4.1, no significant impact on swamp-water quality is expected.

As listed in Table 3-6, Steel Creek has a varied history with regard to the release of reactor effluents. The release of thermal effluents into Steel Creek from L- and P-Reactors reached a peak of about 23 cubic meters per second in 1961. In 1963, P-Reactor effluents were diverted to Par Pond; thus, thermal discharges to Steel Creek were reduced to about 11 cubic meters per second, about 1.3 times the maximum flow expected after heavy rains. Since 1968, Steel Creek has received only infrequent and short-term inputs of thermal effluents (Smith, Sharitz, and Gladden, 1981, 1982; Du Pont, 1982b).

The flow of water in the swamp is altered when the Savannah River is in flood stage (about 27.7 meters) with a flow rate of about 440 cubic meters per second. Under flooding conditions, Four Mile Creek, Pen Branch, and Steel Creek discharge to the Savannah River at Little Hell Landing after they cross an off-site swamp (Creek Plantation Swamp). Data gathered from 1958 through 1980 indicate that, on the average, the Savannah River reaches flood stage at the Savannah River Plant 79 days (22 percent) of each year, predominantly from January through April (see Figure 3-6).

The direct discharge of cooling-water effluent into Steel Creek would require the following: (1) consultations with the FWS, (2) the preparation of a biological assessment for endangered species, (3) an NPDES permit, and (4) a 316(a) demonstration (see Chapter 7). An Army Corps of Engineers 404 permit would not be required.

4.4.2.2.2 Spray canal

A spray system would be added to the cooling-water outlet of L-Reactor to cool the discharged water by spraying it in the atmosphere before it enters Steel Creek. The spray canal (Figure 4-21) would utilize a gravity-power spray cooling system installed in the outfall canal. The system would operate in much the same manner as a conventional pumped spray system by dissipating a portion of cooling-water heat. Vegetation within 300 meters of the spray canal would have to be removed to enhance air circulation and increase cooling efficiency. The estimated time required to design and construct this alternative under normal construction practice is between 18 and 24 months. Penstock construction would not affect reactor operation if the L-Reactor startup occurs before this alternative is implemented. However, pipe header and nozzle installation would require reactor shutdown for 3 to 6 months. The valve chamber could be constructed during reactor operation except for cutting existing pipe and installing valves. These tasks could be performed during the same shutdown used for installing nozzles.

The estimated capital cost for constructing the spray canal is \$9 million, with an annual operating cost of \$3.5 million (Du Pont, 1983d). The present worth of this alternative would be \$38 million and the annualized cost would be \$4.5 million. An estimated 130 construction personnel would be required for the construction of the spray canal.

This alternative would use approximately 11 cubic meters of water per second from the Savannah River. Reactor production efficiency for this option

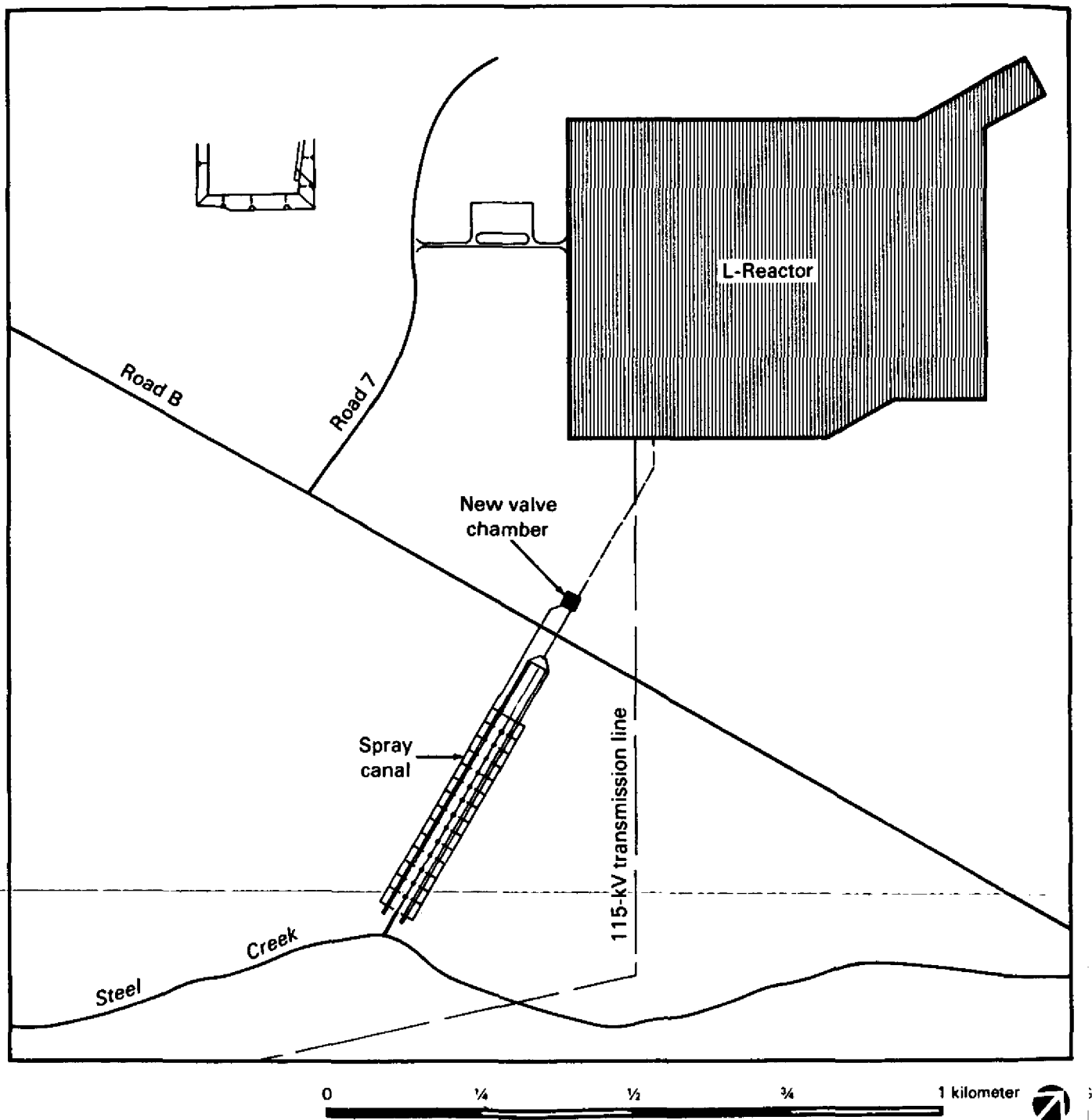


Figure 4-21. Conceptual layout of spray canal.

would be 100 percent. However, the use of reduced power would be necessary to meet State of South Carolina water-quality standards. Table 4-32 lists the estimated downstream temperatures in Steel Creek in the summer, spring, and winter without a reduction of power.

Table 4-32. Temperatures (°C) downstream in Steel Creek with once-through discharge using a spray canal

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	68	66	64	61
Road A	53	52	49	45
Swamp at delta	45	44	40	35
Mid-swamp	37	35	30	25
Mouth of creek at river	34	33	27	21

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature entering Steel Creek.

Compared to direct discharge, the spray canal alternative would provide limited thermal mitigation. The 68°C maximum discharge temperature and the 66°C average summer temperature would both be well above the 32.2°C State discharge limit. Due to the large cooling-water discharge rate (about 10.6 cubic meters per second), Steel Creek temperatures would approach the cooling-water discharge temperature near the outfall, because mixing the discharge with natural flows would result in only a slight temperature reduction.

Implementation of this alternative would result in year-round noncompliance with the State discharge limits. This alternative would not meet discharge limits in Steel Creek but would be in compliance in the Savannah River when a mixing zone is considered.

The implementation of the spray canal alternative would discharge water at about the same rate as direct discharge and would achieve minimal cooling. Thus, the environmental impacts of this alternative would be slightly greater than those for direct discharge; they are summarized as follows:

- Between 730 and 1000 acres of wetlands would be eliminated, including habitat for the endangered American alligator, the endangered wood stork, and migratory waterfowl. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOL, 1981). The mitigation planning goal specifies that there be "no net loss of inkind habitat

value." In addition, about 2500 acres of wetlands could be isolated to aquatic biota by thermal temperatures.

- To achieve optional cooling performance using a spray system, vegetation within 300 meters of the unit would have to be removed. This would impact an additional 55 acres of wetlands and 55 acres of upland conifers. Thus, the total amount of impacted habitat would be 55 acres of uplands and between 785 and 1055 acres of wetlands.
- Approximately 16 fish per day (5840 fish annually) would be impinged; annual entrainment of fish eggs and larvae would be 7.7×10^6 and 11.9×10^6 , respectively.
- Approximately 4.2 curies of radiocesium would be remobilized and transported into the Savannah River during the first year of resumed operations. Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 9340 curies per year.
- Five archeological sites eligible for the National Register would be subject to erosion and flooding, including one prehistoric site and four historic sites.
- Increased flow would further erode the Steel Creek corridor, and delta growth would increase at approximately 3 surface acres per year.

No impact to the substrate, water quality, or naturally occurring turbidity levels would occur as a result of dredging and filling because construction activities would be confined to the existing discharge canal from L-Area during periods of reactor downtime.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, (6) the preparation of a biological assessment for endangered species.

~~If the spray canal cooling system alternative is implemented before direct~~ discharge occurs, the environmental impacts would be slightly greater than those attributable to direct discharge.

4.4.2.2.3 Small lakes

This system, which would use several small dams (rubble dams) on Steel Creek to create small lakes (Figure 4-22), would provide some thermal mitigation to the lower portions of Steel Creek and the swamp compared to the reference case (direct discharge). A series of several rubble dams would create small lakes with a combined area of about 120 acres, which would pool water to provide an increased stream surface area and decreased stream velocity to enhance cooling. The dams would be created by dumping large stone or broken concrete in Steel Creek at accessible locations. The dams would be 1.5 to 2.4 meters high; they could be solid or porous, but better results could be expected with solid dams. Each small dam would consist of about 3500 cubic meters of material; the total volume for the seven dams would be about 24,500 cubic meters. Slightly contaminated spoil from the surface portion of the embankment foundations in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137

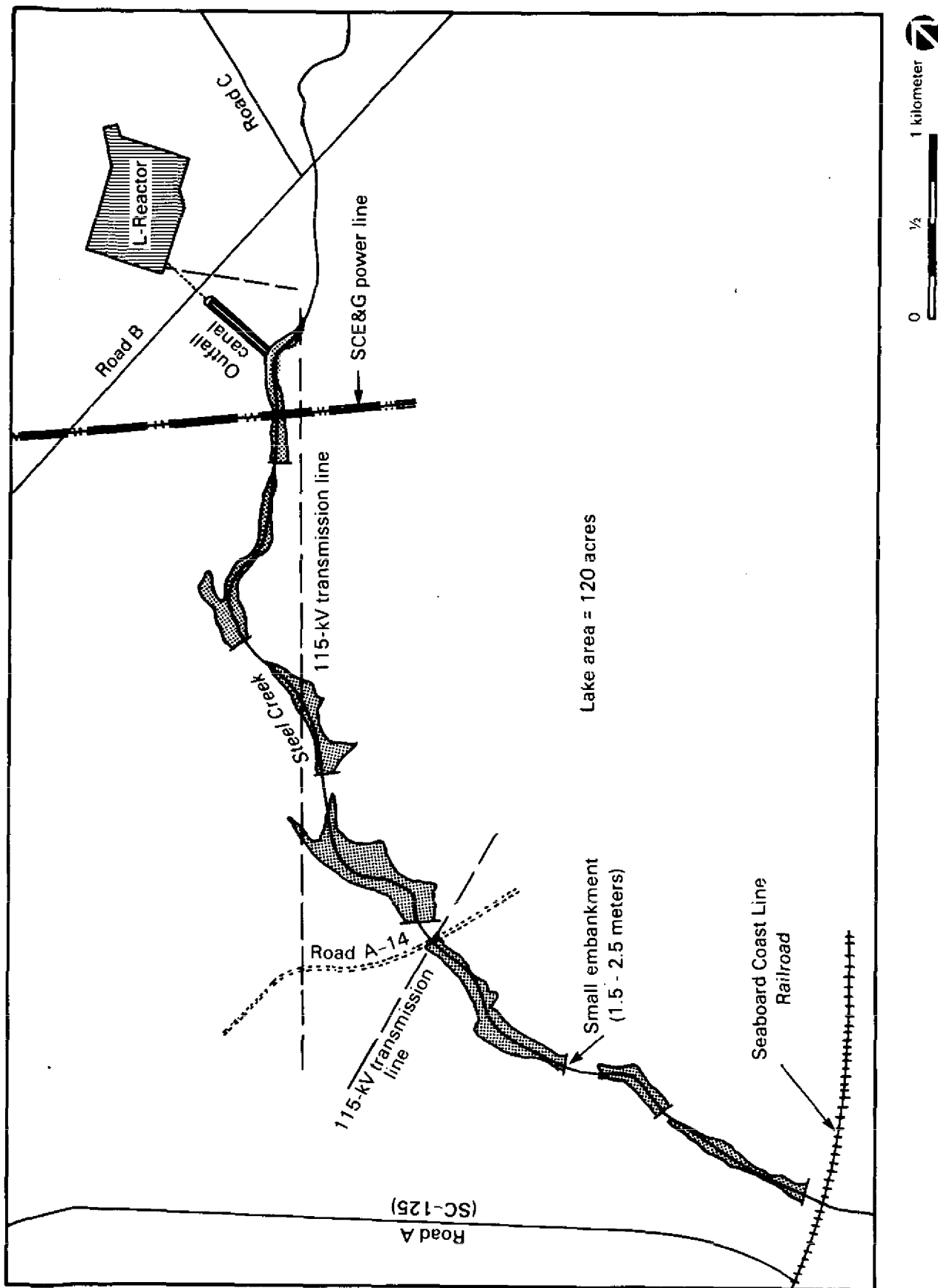


Figure 4-22. Conceptual design for a series of small lakes on Steel Creek.

and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas. Sediment would collect upstream from each solid dam. Water spilling over the dams would increase the heat dissipation effectiveness of the system by increasing the exposure of the hot water to air.

Locations of the dams would be selected to minimize the relocation of existing roads, power lines, and cables and to maximize the potential for cooling in the upper reaches of the creek. Access roads would be minimized and their locations selected to prevent environmental impacts. The estimated time required to design and construct the small rubble dams, without an expedited schedule, is between 18 and 24 months (Du Pont, 1983d). On an expedited schedule, construction of this alternative would be possible in about 6 months. For the construction of these dams, diversion channels would be required around each dam site to reroute heated effluent. These could probably be constructed during a short (1-month) reactor shutdown. Another 1-month period would be required after dam construction is completed to reroute the water back over dams by filling the diversion channels.

The estimated capital costs for small rubble dams would be \$6 million. The annual operating cost would be \$3.4 million, and the present worth would be \$35 million. Annualized cost would be \$4.1 million (Du Pont, 1983d). An estimated 75 personnel would be required for construction of the rubble dams.

Water use for this alternative would be about 11 cubic meters per second. Production efficiency for this alternative would be 100 percent. However, water-quality standards could not be met without a reduction in power.

Small lakes could reduce the temperature at the entry to the swamp to about 40°C, or about 4°C cooler than that for direct discharge, under severe summer conditions. The water discharge temperature from L-Reactor would vary by month, depending on the temperature of the supply water from the Savannah River, meteorological conditions, and the reactor operating power. The temperature at the creek mouth would be about 33°C, or 1°C cooler than for a direct discharge (see Table 4-33).

Small lakes would provide limited thermal mitigation. The 43°C average summer discharge temperature would not comply with the State 32.2°C discharge limit. With the small lakes alternative, water temperatures in the mid-swamp and at the mouth of Steel Creek could be about 7°C above ambient during extreme summer conditions, but would be as much as 15°C above ambient in the winter. This could result in the concentration of fish in the heated areas during the colder months, which, in turn, could subject them to potential cold shock during any shutdown.

The small lakes would result in the loss of between 420 and 580 acres of wetlands in the Steel Creek corridor and between 310 and 420 acres in the delta-swamp area. In addition, about 2500 acres of wetlands could be isolated due to thermal temperatures. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service.

Table 4-33. Temperatures (°C) downstream in Steel Creek with small lakes

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature (from downstream impoundment)	45	43	40	34
Road A	44	42	38	32
Swamp at delta	40	38	34	27
Mid-swamp	34	33	28	21
Mouth of creek at river	33	31	26	18

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions 1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDO1, 1981).

This alternative would have about the same adverse impacts as direct discharge on habitat of the endangered American alligator, the endangered wood stork, and migratory waterfowl.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

The transport of radiocesium down Steel Creek from this alternative would be lower than that for direct discharge. Conservatively, no more than 4.4 ± 2.2 curies would be transported in the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7880 curies per year.

The area subject to impact by this alternative contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. Erosion and transport of sediment are expected to be slightly reduced in relation to direct discharge. A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the impoundments, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the impoundments should be somewhat similar to that of Par Pond; an ion-concentration ratio (impoundment-to-river-water) of less than 1.3 is expected (Tilly, 1974).

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the small impoundments would not begin until the end of the 18- to 24-month construction period.

4.4.2.2.4 Small lakes with upstream spray cooling (one set)

This alternative is very similar to the alternative described in the previous section, except there would be a gravity spray module in the outfall canal. The final lake discharge water would flow at a rate of about 11 cubic meters per second and would be at a temperature of about 44°C under extreme summer conditions.

Small lakes with spray cooling (one set) could be designed and constructed in 18 to 24 months. During the construction (if L-Reactor operation is restarted before construction of the rubble dams), diversion channels would be required around each dam site to route heated effluent around construction areas. These could probably be built during a short (1-month) reactor shutdown. Another 1-month period would be required after construction to reroute water back over the dams by filling the diversion channels. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

~~The estimated capital costs for the small lakes and single spray cooling~~ system would be about \$15 million. Annual operating and maintenance costs would be \$3.5 million, the present worth would be \$44 million, and the annualized cost would be \$5.2 million (Du Pont, 1983e). An estimated 105 construction personnel would be required.

The flow rate for this alternative would be 11 cubic meters per second and the production efficiency would be 100 percent. Table 4-34 lists Steel Creek temperatures for various seasons without a reduction in power. However, the alternative could not meet water-quality standards without a reduction in power.

Discharge temperatures for this alternative would be above the 32.2°C State limit most of the year.

The use of small lakes with a single spray system would result in the loss of between 420 and 580 acres of wetlands in the Steel Creek corridor. The spray canal would also eliminate 55 acres of wetlands and 55 acres of upland habitat. Between 215 and 335 acres of wetlands in the delta and swamp would also be impacted, primarily due to flow. Thus, between 690 and 970 acres of wetlands and

Table 4-34. Temperatures (°C) downstream in Steel Creek with small lakes and one set of spray coolers

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	44	43	39	34
Road A	43	42	38	32
Swamp at delta	40	38	34	27
Mid-swamp	34	32	27	20
Mouth of creek at river	33	31	25	18

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water leaving downstream impoundment.

55 acres of uplands would be effected by this alternative. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOI, 1981). The mitigation planning goal specifies that there be "no net loss of inkind habitat value." In addition, about 2280 acres of wetlands along Meyers Branch and along Steel Creek above the L-Reactor outfall would be isolated from riverine and anadromous fishes.

Effluent temperatures in the mid-swamp during summer and spring would be 7°C to 9°C above ambient. Winter temperatures in the mid-swamp and at the mouth of Steel Creek would be as high as 14°C above ambient. Thus, fishes might be attracted to the mouth of Steel Creek in winter.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Conservatively, the transport of radiocesium down Steel Creek would be less than 4.4 ± 2.2 curies the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7800 curies per year.

The area subject to impact by these alternatives contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Erosion and transport of sediment would increase because of the increased flow rate (about 10.5 cubic meters per second). A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the impoundments, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the impoundments should be somewhat similar to that of Par Pond; an ion-concentration ratio (impoundment-to-river-water) of less than 1.3 is expected (Tilly, 1974).

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental effects would be as described above. If it is implemented after direct discharge occurs, the environmental effects would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from small lakes with one set of spray coolers would not begin until the end of the 18-to 24-month construction period.

4.4.2.2.5 Small lakes with upstream and downstream spray cooling (two sets)

Small lakes with two sets of spray cooling would also mitigate some of the environmental effects of a direct discharge system. The gravity spray canal system would be installed to obtain about 5°C of cooling before the water enters the first pond. The small dams would create pools that would slow the movement of the water and enhance cooling. The second spray system would be in the last shallow pond.

Small lakes with spray cooling (two sets) could be designed and constructed in 18 to 24 months. If L-Reactor operation is restarted before the construction of the rubble dams, the estimated reactor downtime would be between 3 and 4 months to accomplish the tasks. During the construction, diversion channels would be required around each dam site to route heated effluent around construction areas. These could probably be built during a short (1-month) reactor shutdown. Another 1-month period would be required after construction to re-route water back over the dams by filling the diversion channels. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

The estimated capital costs for the small lakes with spray cooling (two sets) would be approximately \$9 million for the spray canal system plus \$5.5 million for the rubble dams plus as much as \$14.5 million for the supplemental spray system; the total cost would be about \$29 million.

Operating and maintenance costs would be higher than those for the direct discharge system because of the added costs of operating the spray modules in the ponds. Annual operating and maintenance costs for this alternative would be \$3.5 million. The present worth of the alternative would be \$60 million and the annualized cost would be \$7.1 million (Du Pont, 1983d). An estimated 135 construction personnel would be required.

Production efficiency for this alternative would be 100 percent. However, State water-quality standards could not be met without a reduction in power. The flow rate would be 10.4 cubic meters per second.

During the passage through these ponds, the water would be cooled to about 43°C under extreme summer conditions. This cooling could be increased by the spray cooling modules in the final lake, where the water would be cooled to about 39°C before being released to Steel Creek above Road A. Table 4-35 lists Steel Creek temperatures for the various seasons without power reduction.

Table 4-35. Temperatures (°C) downstream in Steel Creek with small lakes and two sets of spray coolers

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	39	38	34	29
Road A	39	37	33	27
Swamp at delta	37	35	30	23
Mid-swamp	33	31	26	18
Mouth of creek at river	32	30	24	17

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor (Du Pont, 1983d). Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water leaving downstream impoundment.

The use of small lakes with two spray systems would result in the loss of between 420 and 580 acres of wetlands in the Steel Creek corridor. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of in-kind habitat value" (USDOl, 1981). In addition, about 55 acres of wetlands and 55 acres of uplands would be lost for the construction of the spray canal. Furthermore, 75 acres of uplands would be eliminated by the second spray pond. Between 215 and 335 acres of wetlands in the delta would also be eliminated, primarily by high flow. Thus, between 690 and 970 acres of wetlands and 70 acres of uplands would be eliminated by this alternative. In addition, about 2500 acres of wetlands along Steel Creek above the L-Reactor outfall and along Meyers Branch and Boggy Gut Creek will be isolated from riverine and anadromous fishes.

Effluent temperatures in summer in the mid-swamp and at the mouth of Steel Creek would be as high as 6°C above calculated ambient temperatures. Winter temperatures of 18°C and 17°C (which are 11° to 12°C above ambient) at the swamp and mouth of Steel Creek, respectively, might attract fish. Additional wetlands in the delta and swamp would be eliminated by high flow.

Discharge temperatures for small lakes with two sets of spray cooling are above the 32.2°C State limit. Discharge temperatures over the 32.2°C requirement would occur on most summer days; compliance could be expected during part of the spring and all of the winter months.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Conservatively, the transport of radiocesium down Steel Creek would be no more than 4.4 ± 2.2 curies the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7770 curies per year.

The area subject to impact by these alternatives contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Erosion and transport of sediment would increase because the flow rate would be about 10.4 cubic meters per second. A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the impoundments, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the impoundments should be somewhat similar to that of the Savannah River.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If small lakes with spray cooling (two sets) are implemented before direct discharge occurs, the environmental effects would be as described above. If this alternative is implemented after direct discharge starts, the environmental effects would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from rubble dams with sprays (two sets) would not begin until the end of the 18- to 24-month construction period.

4.4.2.2.6 500-acre lake

The topography along Steel Creek is suitable for the construction of a 500-acre lake (Figure 4-23). The lake would be separated physically into three

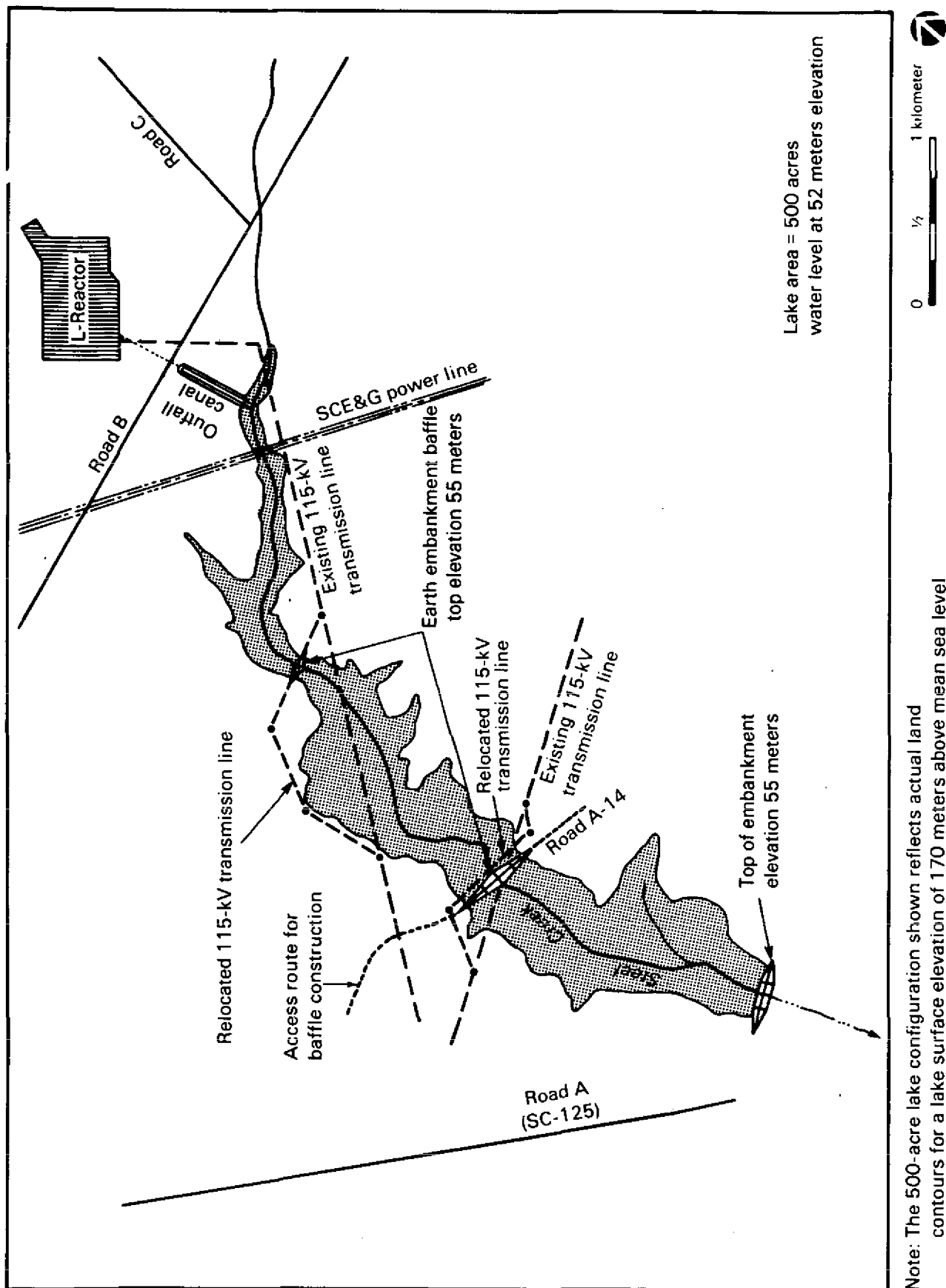


Figure 4-23. Conceptual design of a 500-acre lake on Steel Creek.

sections of about equal length with underflow baffles to enhance its cooling efficiency. The baffles would prevent short circuiting of hot water and would maximize the use of the surface area. The final (underflow) baffle would discharge water from several feet below the lake surface at a rate of about 10.7 cubic meters per second.

The estimated time to design and construct a 500-acre lake, without an expedited schedule, would be 31 months. With an expedited schedule, the lake could be completed in 6 months. If L-Reactor is restarted before this alternative is implemented, a discharge structure could be constructed away from the existing stream while reactor effluent flows continued. When this structure is complete, a short (1-month) shutdown might be required to divert flows through the structure. Also, clearing directly adjacent to the stream would be accomplished during this shutdown.

The construction of the embankment and clearing the 500 acres could be completed while flows are discharged through the structure. Gates in the structure would be closed to fill the 500-acre lake. The construction of the large earthen embankment and baffle structures required for the 500-acre lake would cause some temporary increases in suspended solids in the creek. The quantity of fill material required would be about 450,000 cubic meters. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas. The embankment would be about 475 meters long; it would have a height of about 22 meters. The width at its base would be about 120 meters. Impacts to downstream areas can be minimized by the use of turbidity screens. During construction, the number of access roads would be minimized and their locations selected to prevent environmental impacts.

Water use from the Savannah River would be about 11 cubic meters per second and production efficiency would be 100 percent. The estimated capital cost for a single impoundment is \$12 million; the capital cost would increase by \$2 million if underflow baffles are included. The annual operating cost would be \$3.4 million. The present worth of the lake would be \$41 million, and the annualized cost is \$4.8 million (Du Pont, 1983d). An estimated 345 construction personnel would be required for construction of the 500-acre lake.

Table 4-36 lists the estimated downstream temperatures in Steel Creek in the summer, spring, and winter without reduction in power. This arrangement would minimize diurnal temperature variations in the lake and provide additional cooling capacity during hot weather (about 5°C and 3°C cooler than the direct discharge at the mid-swamp and creek mouth, respectively).

A 500-acre lake would provide limited thermal mitigation. The 37°C discharge temperature from the lake would exceed the State 32.2°C discharge limit. Additionally, the temperature of Steel Creek would increase significantly more than the State temperature increase limit of 2.8°C. The temperatures could be lowered by reducing reactor power.

Table 4-36. Temperatures (°C) downstream in Steel Creek with a single 500-acre lake

Location	Summerna	Summerb	Springb	Winterb
Discharge temperature ^c	37	36	31	24
Road A	37	35	30	24
Swamp at delta	36	34	28	20
Mid-swamp	32	30	24	16
Mouth of creek at river	31	29	23	15

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water leaving lake.

The water temperature at mid-swamp would be 5°C, 6°C, and 10°C above ambient in summer, spring, and winter, respectively (Table 4-36). The water temperature at the mouth of Steel Creek would be 4°C above ambient in summer, 5°C above ambient in spring, and 9°C above ambient in winter. Cold shock to fishes is possible.

The 500-acre lake would impact between 435 and 595 acres of wetlands in the Steel Creek corridor. Approximately 360 acres of uplands would be inundated by the lake. Impacts to wetlands in the delta and swamp due primarily to flow would range between 215 and 335 acres. Thus, this alternative would affect between 650 and 930 acres of wetlands and 360 acres of uplands. Furthermore, approximately 2280 acres of wetlands along Meyers Branch and above L-Reactor would be thermally or physically isolated from riverine and anadromous fishes. Because the lake would achieve an average water temperature of 37°C, it would be biologically devoid of life except for thermophilic flora. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of in-kind habitat value" (USDOI, 1981).

This alternative would have about the same adverse impacts as direct discharge on habitat of the endangered American alligator, the endangered wood stork, and migratory waterfowl.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

The transport of radiocesium down Steel Creek from this alternative would be about the same as that for direct discharge. Conservatively, about 4.4 $\pm$ 2.2 curies would be released during the first year of operation (see Section

L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7880 curies per year.

The area subject to impact by this alternative contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. Mitigation would be similar to that discussed for direct discharge.

Erosion and transport of sediment are expected to be slightly reduced in relation to direct discharge. A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the lake, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the lake should be somewhat similar to that of the Savannah River.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the 500-acre-lake alternative would not begin until the end of the 18- to 31-month construction period.

4.4.2.2.7 500-acre lake with spray cooling (one set)

The cooling efficiency of the 500-acre lake (Figure 4-23) could be enhanced through the addition of a spray module. The gravity-power spray cooling system (Figure 4-21 and Section 4.4.2.2.2) would operate in much the same manner as a conventional pumped spray system by dissipating a portion of cooling-water heat into the atmosphere.

The estimated time required to design and construct the lake is a total of 31 months without expediting. On an expedited basis, the lake could be constructed in 6 months. Assuming that the permit process for the lake begins when the design of the spray canal is initiated, then the lake construction would be completed about 19 months after the spray canal. This schedule assumes that there would be no major permitting delays. Before the implementation of this alternative could begin, a budget proposal would have to be submitted to the U.S. Congress to seek funding appropriations.

The construction of the spray system would begin after permits have been obtained from the appropriate State and Federal agencies. The estimated time required to design and construct the spray system is about 12 months (on an expedited basis). A new valve chamber (shown in Figure 4-21) and a penstock would be installed as part of the spray canal system, along with pipe headers

and nozzles. L-Reactor operation would begin at the same time the construction of the spray canal and the lake get underway.

Provisions would be made for the diversion or controlled channeling of more than 11 cubic meters per second of increased water flow that would occur when L-Reactor begins operation. The water flow would include L-Reactor cooling water, storm runoff, and natural Steel Creek flows. This water would be diverted around active construction areas.

Depending on when the diversion around the construction area first occurs, a short shutdown (about 1 month) might be required to implement the diversion. Clearing the vegetation directly adjacent to the stream could be accomplished during this shutdown. When the embankment is completed and the land is cleared, the control gates in the diversion structure would be closed to fill the lake.

The construction of the earthen embankment, baffle structures, and water diversion system for the lake would cause some temporary increases in suspended solids in the creek. Suitable precautions would be taken (1) during the construction operations necessary to establish a foundation for the impoundment, (2) during any necessary diversion of Steel Creek, and (3) during emplacement of the fill to ensure that undue silt and debris loads do not move downstream from the construction site. Turbidity screens could minimize impacts to downstream areas. About 450,000 cubic meters of fill material would be required for the dam and baffles.

Borrow pits of suitable materials and similar quantities have been used in the past for similar construction at the Savannah River Plant. For this alternative, the most economically suitable pit would be identified and controlled. Spoil piles of the size expected for this alternative have been developed for past construction activities at the Savannah River Plant and have met necessary environmental control requirements.

During construction, the location and number of access roads would be minimized to reduce environmental impacts. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

Capital costs for the combined lake-and-spray system would be approximately the \$9-million cost of the spray canal system plus the \$12-million cost of the 500-acre lake, a total cost of about \$21 million. Underflow baffles would increase the capital cost by about \$2 million. Operating and maintenance costs would be about the same as those for direct discharge if a gravity spray system is utilized (\$3.5 million). The present worth of this alternative would be \$50 million and the annualized cost would be \$5.9 million (Du Pont, 1983d). An estimated 375 construction personnel would be required.

Approximately 11 cubic meters per second would be withdrawn from the Savannah River and used as the secondary cooling-water supply. Production efficiency

would be 100 percent. However, reactor operation would be limited in the summer by the ambient temperature of the Savannah River.

Table 4-37 lists the estimated downstream temperatures in Steel Creek for the summer, spring, and winter without a reduction in power. Ambient temperatures in Steel Creek at Road A are about 25°C in summer, 20°C in spring, and 7°C in winter; this is based on 10 years of measurements (Du Pont, 1983d).

Table 4-37. Temperatures (°C) downstream in Steel Creek with a 500-acre lake with spray cooling (one set of sprays)

Location	Summerna	Summerb	Springb	Winterb
Discharge temperature ^c	37	35	30	23
Road A	37	35	30	23
Swamp at delta	36	33	28	20
Mid-swamp	32	30	24	16
Mouth of creek at river	31	29	23	15

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor (Du Pont, 1983d). Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above conditions and below average did not occur.

^cTemperature of water leaving lake.

The gravity spray canal system would provide about 5°C cooling in the summer before the water entered the 500-acre lake. This water (at 73°C) would be cooled to about 37°C during its travel through the lake (under worst-case meteorological conditions). As shown in Table 4-37, this alternative would exceed the 32°C discharge temperature limit on extreme summer days but would be in compliance on average summer days. These temperatures could be reduced by a reduction in power.

The environmental consequences of using a cooling system with one set of sprays until a 500-acre lake became operational would include impacts from the elevated water temperature and the increased rate of flow.

The construction of the spray canal (Section 4.4.2.2.2) would necessitate the removal of vegetation within 300 meters of the unit to achieve the best cooling performance, causing a slightly greater impact on wetlands than direct discharge. These impacts from the spray canal alone (until the lake is constructed), which would result from high water temperatures (i.e., $\Delta T = 8^\circ\text{C}$ at the swamp in summer) and flow rate (about 10.6 cubic meters per second) include:

- Between 705 and 985 acres of wetlands would be eliminated, including habitat for the endangered American alligator, the endangered wood

stork, and migratory waterfowl. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOl, 1981). In addition, about 2500 acres of wetlands would be isolated to aquatic biota by thermal temperatures, and 415 acres of uplands would be inundated.

- Approximately 16 fish per day (5840 fish annually) would be impinged; annual entrainment of fish eggs and larvae would be 7.7×10^6 and 11.9×10^6 , respectively.
- Conservatively, no more than 4.4 ± 2.2 curies of radiocesium would be remobilized and transported into the Savannah River during the first year of resumed operations (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 9340 curies per year.
- Five archeological sites eligible for the National Register would be subject to erosion and flooding, including one prehistoric site and four historic sites. A mitigation plan would be designed by the Institute of Archeology and Anthropology of the University of South Carolina and would be completed prior to restart.
- Increased flow would further erode the Steel Creek corridor, and delta growth would increase at approximately 3 surface acres per year.

No impact to the substrate, water quality, or naturally occurring turbidity levels would occur as a result of dredging and filling because construction activities would be confined to the existing discharge canal from L-Area during periods of reactor downtime.

The construction of the 500-acre lake would cause short-term impacts to the substrate, water quality, and naturally occurring turbidity levels of Steel Creek as a result of dredging and filling.

The lake would impound about 6 kilometers of Steel Creek from the L-Reactor outfall to its dam near Road A (SC Route 125). Biota would have already been eliminated in this portion of the creek from the operation of the spray cooling system. Because the lake would achieve an average water temperature of 37°C, it would be biologically devoid of life except for thermophilic flora. It could also thermally isolate Meyers Branch and physically isolate the upper reaches of Steel Creek (about 2280 acres of wetlands) from fishes and other aquatic and semiaquatic biota. Access to wetlands associated with Boggy Gut Creek (about 230 acres) will be unaffected.

The rate of flow of the effluent discharged below the dam for this once-through alternative would be about 10.5 cubic meters per second. The temperature of the effluent in summer would be 37°C.

In spring, water temperatures in the mid-swamp and at the mouth of Steel Creek would be within 6°C of calculated ambient temperatures (Table 4-37). Thus, anadromous and riverine fishes would have access to the swamp for spawning

and foraging. Winter temperatures in the swamp and at the mouth of Steel Creek would be about 10°C and 9°C above ambient, respectively. Although there is a potential for fishes to concentrate in these warmer waters during the winter, no adverse impacts to the Savannah River due to effluent discharge are expected. Although this option would achieve thermally viable water temperatures in the swamp and at the mouth of Steel Creek, the discharge rate below the dam would have adverse impacts on the Steel Creek delta and portions of the swamp. The flow and scouring effect of the effluent would uproot most of the existing vegetation almost immediately; the remaining vegetation would eventually succumb to high flow. Other wetland vegetation would experience elevated water levels, and their root systems would be inundated. Mortality, especially after continuous inundation, would occur to even the most water-tolerant species (i.e., willow and alder).

An estimated 215 to 335 acres of wetlands would be eliminated in the Savannah River swamp and Steel Creek delta. This would include important foraging habitat for the endangered wood stork. In addition, important roosting and feeding habitat for as many as 1200 mallard ducks and 400 wood ducks would be lost. There would be negligible impact to the American alligator below the Steel Creek delta.

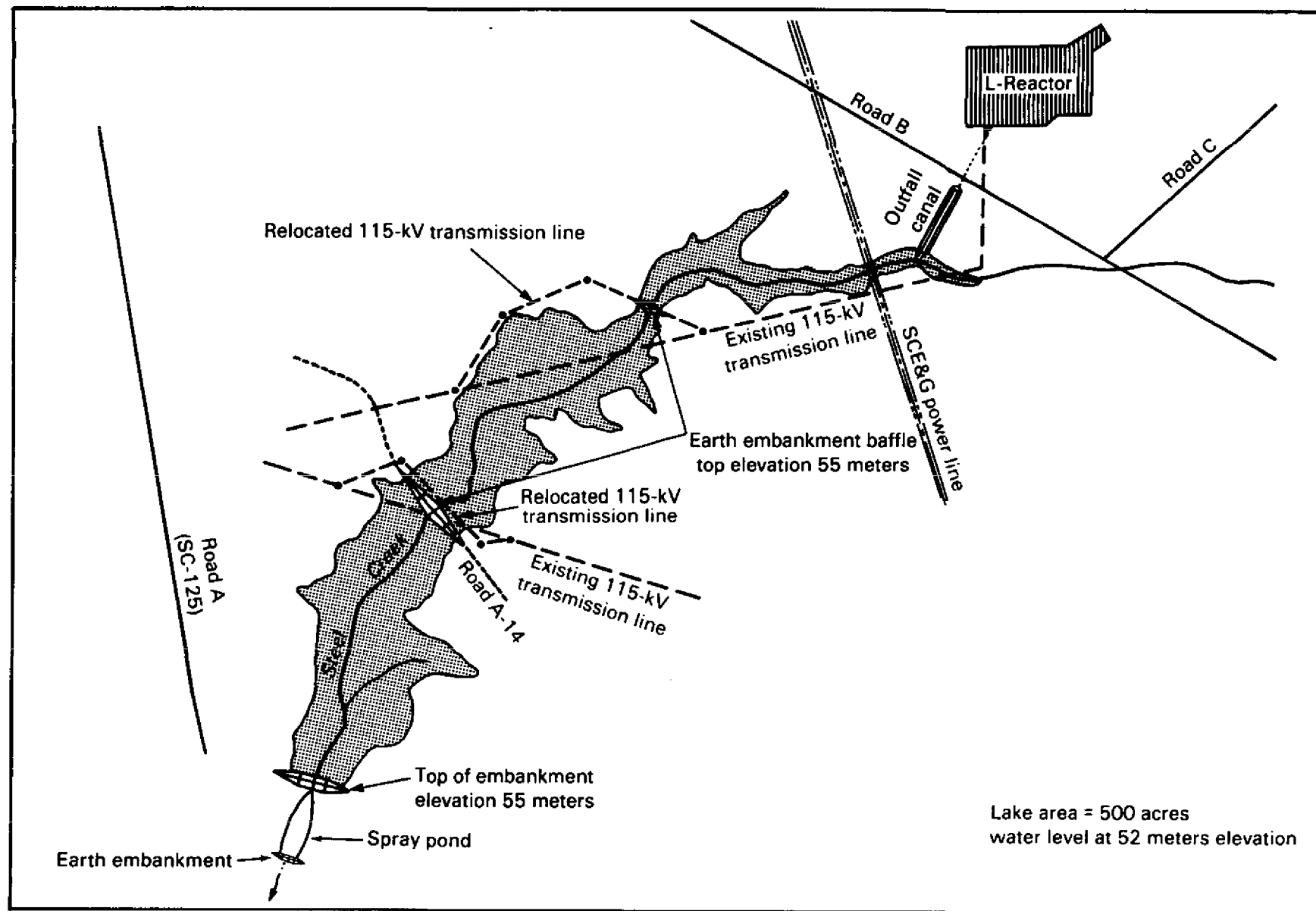
This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the mitigative effects would be that riverine and anadromous aquatic biota would have access to the Savannah River swamp.

4.4.2.2.5 500-acre lake with spray cooling (two sets)

Another alternative system would combine the 500-acre lake with two spray cooling systems. The gravity spray canal system described in Section 4.4.2.2.2 would be installed to obtain about 5°C of cooling in the summer before the water enters the 500-acre lake. This water would be cooled to about 37°C during its travel through the lake under extreme summer conditions. A spray system below the dam would cool the water to about 32°C before discharging it to Steel Creek (Figure 4-24). To reduce energy requirements (and, thus, operating and maintenance costs), the hydraulic head created by the lake would be used to power a gravity spray system below the dam.

The combined lake-and-spray system could be designed and constructed on a normal schedule within the same 31-month timespan that the lake alone would require. The 31-month schedule would assume that construction permits could be obtained with no major delays. An accelerated schedule could shorten this time. Implementation would also be contingent on funding. The three components could be built simultaneously; the embankment construction would be the limiting feature of the schedule. The reactor downtime would be from 3 to 6 months. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during



Note: The 500-acre lake configuration shown reflects actual land contours for a lake surface elevation of 170 meters above mean sea level

0 1/2 1 kilometer



Figure 4-24. Conceptual design of a 500-acre lake (two spray systems) on Steel Creek.

the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

Capital costs for the combined lake-and-spray system would be approximately the \$9-million cost of the spray canal system plus the \$12-million cost of the 500-acre lake plus about \$15 million for the additional spray system; the total cost would be about \$36 million. If underflow baffles are included, capital costs would increase by \$2 million. Operating and maintenance costs would be about the same as those for direct discharge (\$3.5 million) if gravity spray systems are utilized. The present worth of this alternative would be \$65 million and the annualized cost would be \$7.6 million (Du Pont, 1983d). An estimated 405 construction personnel would be required.

Approximately 11 cubic meters per second would be withdrawn from the Savannah River and used as the secondary cooling-water supply. Production efficiency would be 100 percent. However, reactor operation would be limited in the summer by the ambient temperature of the Savannah River.

Table 4-38 lists the estimated downstream temperatures in Steel Creek for the summer, spring, and winter without reduction in reactor power. The 500-acre lake with two sets of spray coolers would normally comply with the maximum discharge temperature of 32.2°C during extreme meteorological conditions.

Table 4-38. Temperatures (°C) downstream in Steel Creek with a 500-acre lake with spray cooling (two sprays)

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	32	30	25	18
Road A	32	30	25	18
Swamp at delta	32	30	24	16
Mid-swamp	30	28	22	13
Mouth of creek at river	30	28	22	13

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water leaving lake.

The environmental impacts of this alternative are summarized as follows:

- This alternative would significantly reduce thermal impacts. Summer and spring temperatures in the mid-swamp and at the mouth of Steel Creek would be within 4°C of ambient. Water temperatures in the swamp and at

the mouth of Steel Creek in winter would be as high as 7°C above ambient. Thus, temperatures in the winter could cause fish to concentrate near the mouth of Steel Creek, and also subject them to cold shock.

- Approximately 705 to 985 acres of wetlands would be affected, including habitat of the endangered American alligator, the endangered wood stork, and migratory waterfowl. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). In addition, 490 acres of upland habitat would be inundated. About 100 acres of wetlands would be isolated by this alternative.
- Approximately 16 fish per day (5840 fish annually) would be impinged; the annual entrainment of fish eggs and larvae will be 7.7×10^6 and 11.9×10^6 , respectively.
- Conservatively, no more than 4.4 ± 2.2 curies of radiocesium would be remobilized and transported to the Savannah River during the first year of resumed L-Reactor operation (see Section L.4.1.2.2). Liquid releases of tritium would be about 7670 curies per year.
- Five archeological sites eligible for the National Register would be subject to erosion and flooding, including one prehistoric site and four historic sites. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.
- The increased flow (to about 10.4 cubic meters per second) would further erode the Steel Creek corridor, and delta growth will increase at a rate of approximately 2 surface acres per year.
- Short-term impacts to the substrate, water quality, and naturally occurring turbidity levels would occur as a result of dredging for the construction of dams and spray systems. These impacts are discussed in Section 4.4.2.2.3.
- Local ground-water levels would be raised due to the reservoir.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If the 500-acre lake with two spray cooling systems is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.2.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The primary mitigative effect resulting from this alternative would be that riverine and anadromous aquatic biota could inhabit the Savannah River swamp system, Meyers Branch, and Boggy Gut Creek.

4.4.2.2.9 1000-acre lake

This alternative consists of a 1000-acre once-through cooling lake on Steel Creek (Figure 4-25). The normal water surface elevation would be 58 meters above mean sea level. The embankment for this cooling lake would be at the same location as that for the 500-acre lake described in Section 4.4.2.2.6. This alternative would require the relocation of two 115-kilovolt electric transmission lines and buried supervisor control and relay cable lines that cross Steel Creek near Road A-14. Roads A-14, A-14.1, and B-5 would have to be abandoned.

The lake would have a length of about 7000 meters including about 1500 meters of tailwater upstream of the outfall canal. The embankment would be about 750 meters long, 28 meters high, and 210 meters wide at its base. The water would be discharged several meters below the top of the embankment. Several small earthen berms would be required to prevent high water from overflowing natural saddles into adjacent watersheds. One of these points could be controlled for use as an emergency spillway to prevent unusually large storm flows from overtopping the embankment.

The construction of the 1000-acre lake would begin after permits had been obtained from the appropriate State and Federal agencies. The estimated time for the design and construction of this alternative would be about 36 months without an expedited schedule. This schedule assumes there would be no major permitting delays. With an expedited schedule, this alternative could be completed in 6 months, as discussed in Section 4.5 and Appendix L.

The construction of the earthen embankment, baffle structures, and water diversion system for the lake would cause some temporary increases in suspended solids in the creek. Suitable precautions would be taken (1) during the construction operations necessary to establish a foundation for the impoundment, and (2) during emplacement of the fill to ensure that undue silt and debris loads do not move downstream from the construction site. Turbidity screens could minimize impacts to downstream areas. About 1.2 million cubic meters of fill material would be required for the embankment.

~~Borrow pits of suitable materials and similar quantities have been identified~~ in the past for similar construction at the Savannah River Plant, and have been controlled in an environmentally acceptable manner. For this alternative, the most economically suitable pit would be identified and similarly controlled.

Spoil piles of the size expected for this alternative have been developed for past construction activities at the Savannah River Plant and have met necessary environmental control requirements. In one case, special precautions were taken to protect a Thermal Effects Laboratory operated for environmental purposes on Upper Three Runs Creek. These measures were completely successful. Spoil from any excavation in the former floodplain of Steel Creek would be monitored for radioactive species; contaminated spoil would be disposed of in a suitable manner. During construction, the location and number of access roads would be minimized to reduce environmental impacts. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and

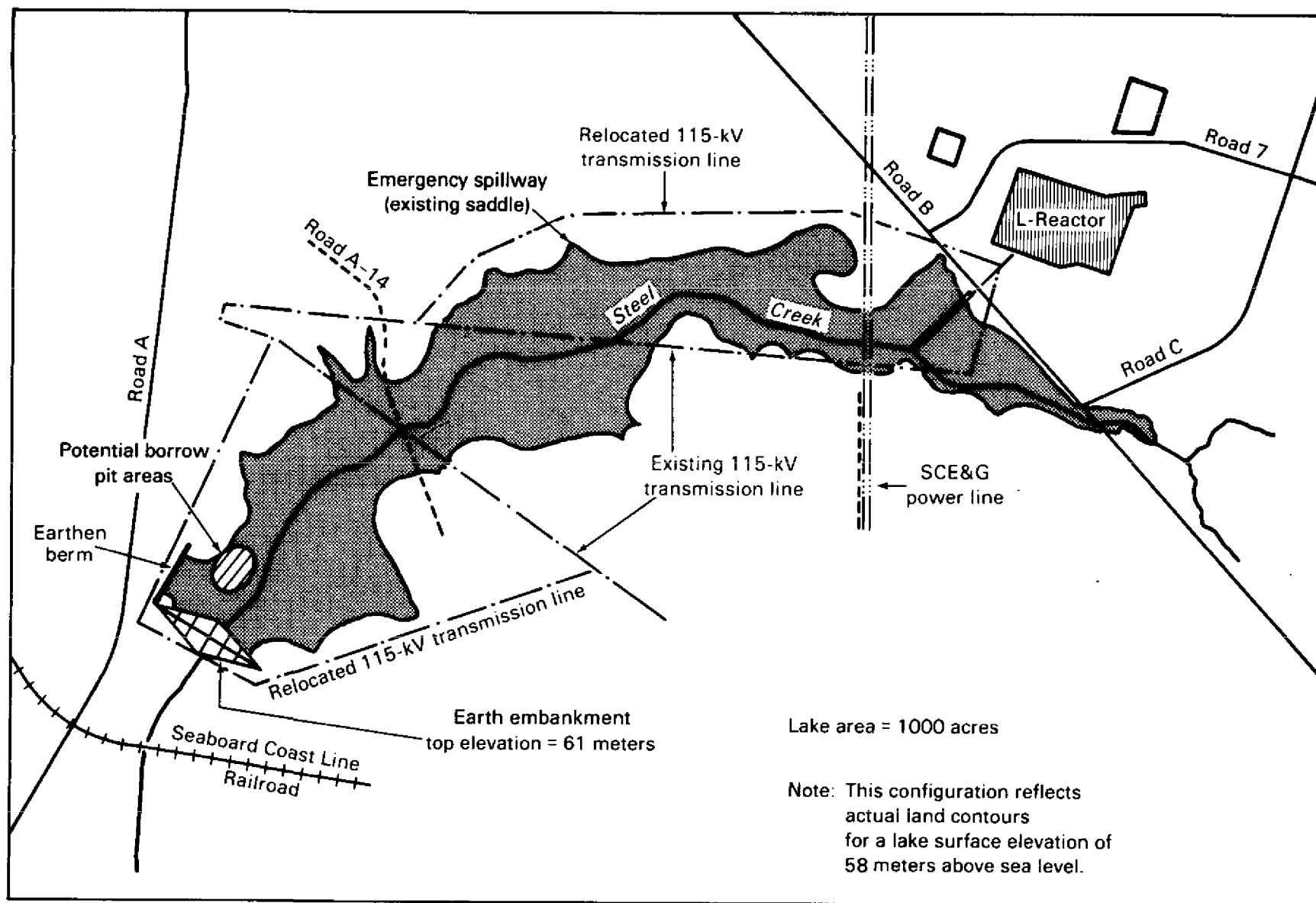


Figure 4-25. Conceptual design for 1000-acre lake on Steel Creek.

covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

Capital costs for the 1000-acre lake would be approximately \$25 million. Operating and maintenance costs would be about \$3.4 million. The present worth of this alternative would be \$56 million and the annualized cost would be \$6.6 million (Du Pont, 1983d). An estimated 550 workers would be required for the construction of the lake.

Approximately 11 cubic meters per second would be withdrawn from the Savannah River and used as the secondary cooling-water supply. Production efficiency would be 100 percent. However, reactor operation would be limited in the summer by the ambient temperature of the Savannah River.

Table 4-39 lists the estimated downstream temperatures in Steel Creek for the summer, spring, and winter without reduction in power (Du Pont, 1983d). These temperatures could be lowered by a reduction in reactor power, as discussed in Section 4.5 and Appendix L. The 1000-acre lake without power reductions would probably be uninhabitable to aquatic and semiaquatic biota. A depauperate biological community could exist in the lower reaches of the impoundment near the embankment. Projected water temperatures in the summer (5-day worst-case) at the Steel Creek delta, the mid-swamp, and the mouth of Steel Creek would be within 2°C of ambient. In the spring, water temperatures at Steel Creek delta would be 3°C above ambient. Water temperatures would be near ambient at the mouth of Steel Creek. These conditions do not pose any adverse impacts to aquatic and semiaquatic biota. In the winter, however, projected temperatures at Road A and points downstream would be 7° to 9°C above ambient. These warmer conditions could concentrate fish at the mouth of Steel Creek, and also cause the phenomenon of cold shock. This alternative would not adversely impact access and spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta.

Table 4-39. Temperatures (°C) downstream in Steel Creek with a 1000-acre lake

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	34	32	26	17
Road A	34	32	26	17
Swamp at delta	34	31	25	15
Mid-swamp	31	29	22	13
Mouth of creek at river	31	28	22	13

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor.

^cTemperature of water leaving lake.

The habitat impacted by the 1000-acre lake alternative would include between 520 and 680 acres of wetlands in the Steel Creek corridor. The lake would also inundate 775 acres of uplands. An additional 100 acres of uplands would be impacted due to the relocation of electric and cable rights-of-way. The flow rate would adversely impact between 215 and 335 acres of wetlands in the Steel Creek delta and swamp that provide foraging habitat for the endangered wood stork and the endangered American alligator. These wetlands also represent important feeding and roosting habitat for as many as 1200 mallard and 400 wood duck. It could also prevent access by riverine and anadromous fish in summer to about 2280 acres of wetlands along Steel Creek above L-Reactor and along Meyers Branch. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOJ, 1981).

Because this alternative would require approximately 11 cubic meters per second of Savannah River water, the impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Conservatively, the transport of radiocesium down Steel Creek from this alternative would be no more than 4.4 ± 2.2 curies the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7880 curies per year.

Four historic sites and one prehistoric site in the Steel Creek terrace and floodplain system have been determined to be eligible for inclusion in the National Register of Historic Places. No direct impacts are expected to the prehistoric site or to three of the historic sites because they would be below the embankment and outside the area affected by high-water flow conditions. One historic site area would be inundated when the lake was filled. In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described as of ephemeral quality and not eligible for nomination to the National Register. Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation will be completed prior to restart (Hanson, 1984). The study results, determination eligibility of potential sites, and the development of a mitigation plan are being coordinated with the SHPO and ACHP.

Erosion and transport of sediment are expected to be slightly reduced in relation to direct discharge. A delta growth of about 1 to 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the lake, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin

and the impoundments. The ground-water level would be altered in the vicinity of the lake.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, (6) the preparation of a biological assessment for endangered species, and (7) consultation with the SHPO for archeological resources.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the 1000-acre-lake alternative would not begin until the end of the construction period.

4.4.2.2.10 Penstock diversion to Pen Branch/lake-canal diversion to Pen Branch

Heated secondary coolant leaving L-Reactor could be diverted to Pen Branch, which presently carries heated effluent from K-Reactor back to the Savannah River. Because of physical location, the input to Pen Branch from L-Reactor would occur a few kilometers upstream of the point at which Indian Grave Branch, which receives K-Reactor discharges, joins Pen Branch.

Two possible methods of water diversion to Pen Branch have been evaluated. They are (1) by penstock and canal (Figure 4-26) and (2) by lake and canal (Figure 4-27).

Under the first option, cooling effluent from L-Reactor would be diverted through an underground pipe that would begin at the 904-L sump, which is where secondary cooling water from L-Reactor accumulates after passing through the reactor heat exchangers. The pipe would convey the flow to the northwest, about 1200 meters to the north side of SRP Road 7, where it would discharge into an open canal. The water would flow through the canal about 1000 meters to Pen Branch. No pumping would be required in either the pipe or the canal. ~~Structural improvements to bridges crossing Pen Branch might be required because of~~ increased flows.

The estimated minimum time required to design and construct this alternative is 38 months (Du Pont, 1983d). All construction would take place away from Steel Creek. Therefore, L-Reactor shutdown would be required for approximately 1 to 2 months for the installation of a pipe connection and valves.

For the penstock-and-canal diversion to Pen Branch, the estimated capital cost would be \$7 million. The annual operating cost would be \$3.4 million and the present worth would be \$36 million. The annualized cost would be \$4.2 million. An estimated 120 construction personnel would be required.

Water requirements for the penstock-and-canal diversion to Pen Branch would be 11 cubic meters per second. Production efficiencies would be 100 percent. During summer periods of high river temperatures, reactor operating power would be reduced, though the same flow rate would be maintained.

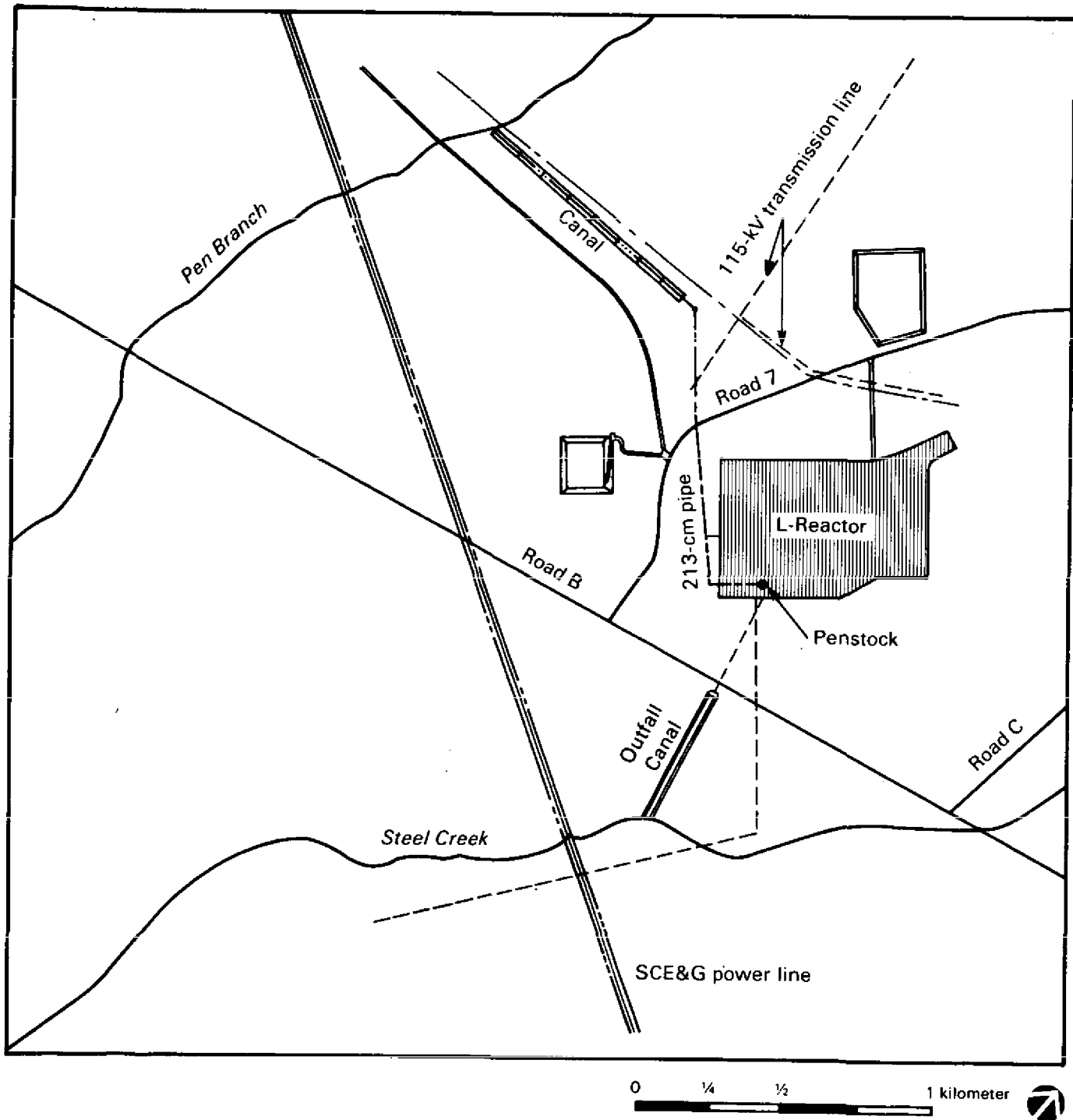


Figure 4-26. Discharge of cooling water to Pen Branch by penstock and canal.

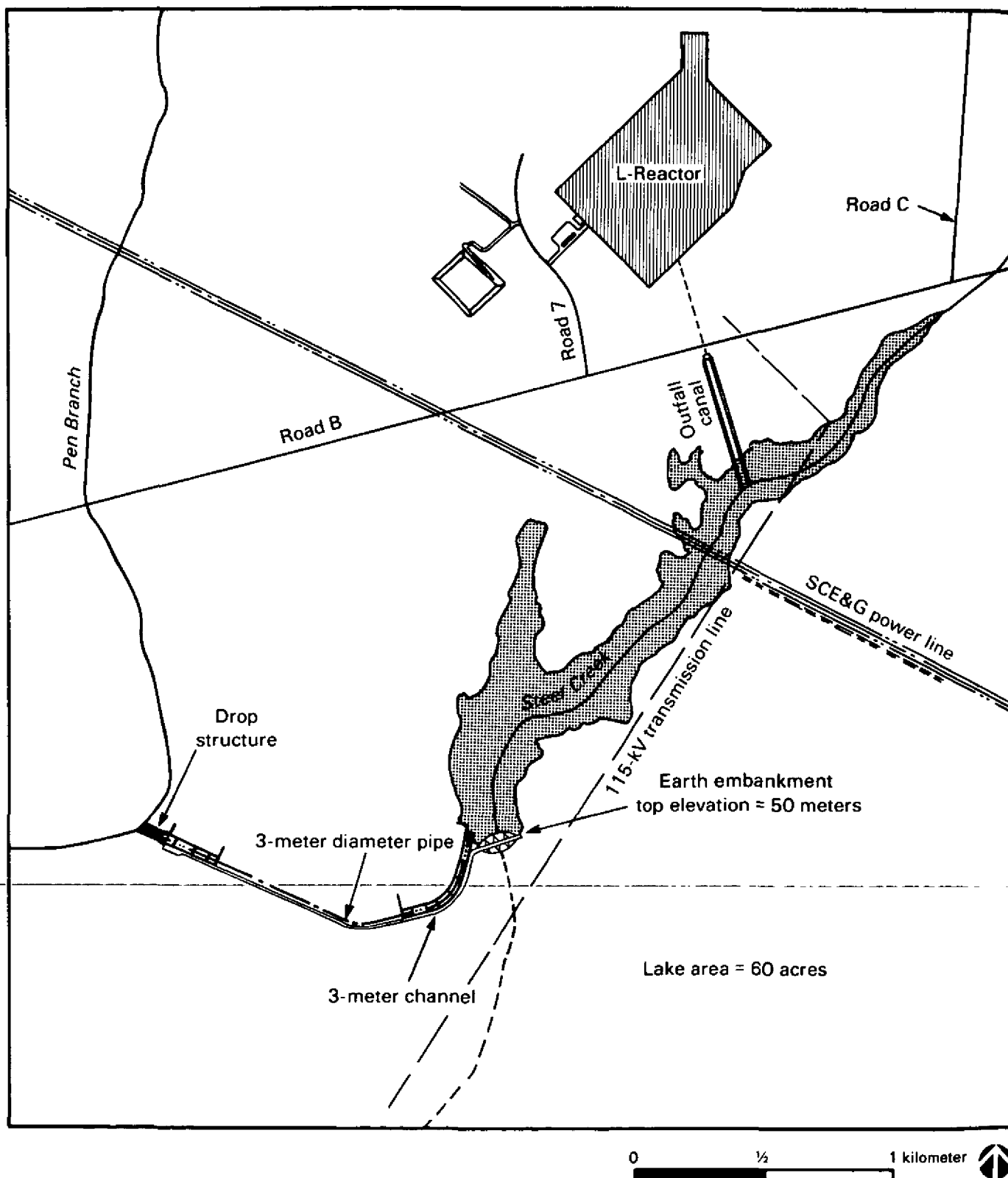


Figure 4-27. Diversion of cooling water to Pen Branch by lake and canal.

Although Steel Creek temperatures would not be increased above ambient, Pen Branch would receive about 11 cubic meters per second of water at 73°C, which exceeds the State limit of 32.2°C. The reported temperature (73°C) is for extreme summer meteorological conditions and reflects reduced reactor operating power due to elevated Savannah River temperatures. A previously unaffected 5-kilometer portion of Pen Branch would experience increased temperatures well above ambient.

The second diversion option would require an earthen embankment in Steel Creek about 1500 meters downstream from the L-Reactor effluent canal discharge. The embankment would require 17,000 cubic meters of material. Truck access roads for embankment construction would be routed to minimize environmental impacts. The embankment would form a small (60-acre) lake (Figure 4-27) to provide additional cooling. A canal and a pipe with a combined length of about 1400 meters would divert the flow from the lake to Pen Branch. Just north of Road A, the diversion from Steel Creek would join Pen Branch, which carries the effluent stream discharged from K-Reactor. No pumping would be required.

A diversion of L-Reactor effluent would cause extensive additional impacts to the Pen Branch system. The penstock-and-canal alternative would impact approximately 5 kilometers of the stream, or 55 acres of wetland that have not been impacted by earlier reactor operations. In addition, about 210 acres of the Pen Branch delta and 960 acres of the Savannah River swamp would be affected. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). Construction of the canal would affect 10 acres of upland habitat. No wetlands (i.e., Steel Creek above L-Reactor, Meyers Branch, or Boggy Gut Creek) would be isolated by this alternative.

With a lake and canal, a discharge structure could be constructed away from the existing stream to carry reactor effluent. The diversion pipe, canal, and drop structure could be constructed and most clearing completed during this time. The estimated time required to design and construct this alternative would be 33 months.

For the lake-and-canal diversion to Pen Branch, the estimated capital cost would be \$4 million. The annual operating cost would be \$3.4 million, and the present worth would be \$33 million. Annualized costs would be \$3.9 million. An estimated 315 construction personnel would be required.

Water use from the Savannah River for the lake-and-canal diversion would be 11 cubic meters per second. The production efficiency would be 100 percent.

Thermal impacts are not expected in Steel Creek below the 60-acre lake and embankment. The lake-and-canal alternative would cause approximately 4 kilometers of unimpacted stream and floodplain along Pen Branch to receive heated effluent at about 73°C during extreme summer meteorological conditions. A total of about 1280 acres of wetlands would be impacted by the lake-and-canal alternative, including (1) Pen Branch (50 acres), (2) Steel Creek (60 acres), (3) Pen Branch delta (210 acres), and (4) the Savannah River swamp (960 acres). These wetlands are also classified as Resource Category 2 by the FWS (USDOI, 1981).

About 10 acres of uplands would be affected by the construction of the canal. This alternative would isolate about 100 acres of wetlands above the embankment. The temperature at the Pen Branch entry to the swamp would be about 58°C and the temperature at the mouth of Steel Creek would be 30°C in summer. The lake-and-canal diversion to Pen Branch would result in discharge water temperatures well above the 32.2°C State discharge limit.

A reactor shutdown of about 1 month would allow the diversion of stream flows through the discharge structure and the clearing of land adjacent to the stream. The dam would be constructed and the discharge stopped to fill the lake and divert flows to Pen Branch.

Any alternative involving a diversion to Pen Branch would result in average water temperatures at the mouth of Steel Creek of 29°C in summer, 23°C in spring, and 18°C in winter without power reduction. This would be about 2°C above ambient in summer, and spring, and 6°C above ambient in winter.

The penstock-and-canal alternative would not have a direct impact on aquatic habitat in Steel Creek upstream from the swamp. However, the lake-and-canal alternative, in addition to diverting L-Reactor effluent to Pen Branch, would convert the upper reach of Steel Creek into a tributary of Pen Branch, which is much less productive biologically due to long-term thermal impacts from the operation of K-Reactor. The thermal effluent discharging into this modified stream would eliminate any access to the upper reach of Steel Creek during the operation of either K- or L-Reactor. Aquatic organisms in the upper reach that survive these modified conditions would become isolated unless neither reactor were operational.

Either alternative would result in a loss of habitat in the lower reaches of Pen Branch due to increased flows of heated water. This would occur primarily in backwater areas that have not been impacted directly by the main thermal stream.

The occurrence of resident alligators above the Pen Branch delta is unlikely (Murphy, 1981), although the 7800-acre swamp bordering the Savannah River might support a small population. ~~The impact of this option on endangered and threatened species is considered to be insignificant.~~

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Radiocesium transport would consist of about 0.25 curie per year from Steel Creek plus a component from Pen Branch. About 0.15 curie would be remobilized and transported in Pen Branch to Steel Creek during the first year of resumed L-Reactor operation. The total transport from Steel Creek is estimated to be 0.4 curie per year. Liquid releases of tritium from L-Reactor would be about 9600 curies per year.

An estimated seven or eight archeological sites are assumed to be impacted by this alternative as the result of the construction of the diversion canal and the increased flow down Pen Branch. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Additional impacts to existing aquatic habitat in Pen Branch would result from erosion and sedimentation effects. The stream flow would increase to about ten times normal in the upper reach between the points of entry into the stream of the L-Reactor and K-Reactor discharges. The increased erosion, downcutting, widening, and straightening of the stream would result in the loss of existing aquatic habitat. In addition, erosion would be expected in the lower reach where, with either option, the stream flow would be twice the present flow. Changes in sedimentation due to either alternative would result in the Pen Branch delta growth rate reaching about 18 acres per year.

The chemical characteristics of the L-Reactor liquid effluent are estimated to be similar to those of Steel Creek and the Savannah River, and not unlike those presently being discharged by K-Reactor to Pen Branch. No appreciable change is expected in the characteristics of the effluent as it flows through the lake-and-canal system, except about 4 percent of the suspended sediment load would be lost. About 100 metric tons of silt and clay would be deposited in the lake each year.

Additional impacts would be caused by changes in existing stream flow patterns. The diversion of flows from upper Steel Creek would reduce flows in the lower reaches of this stream, thereby modifying or eliminating some existing aquatic habitat, particularly in backwater areas.

These alternatives would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If either of the Pen Branch diversion alternatives is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge begins, the environmental impacts would be the same as those described in Section 4.2.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from the penstock/canal diversion alternative would include no impacts to wetlands of the Steel Creek corridor (i.e., 420 to 580 acres); the lake/canal alternative would cause no impacts to wetlands below the dam. Between 1225 and 1280 acres of wetlands associated with Pen Branch and the Savannah River swamp, however, would be impacted. Mitigative effects would not begin until the end of the 18-month construction period.

4.4.2.3 Cooling towers

The following sections describe three types of cooling towers--once-through, recirculation, and partial-recirculation. Figure 4-28 shows the estimated discharge-water temperatures for cooling towers with 2.8°C, 5.6°C, and 8.4°C approach temperature designs, which are based on recorded average wet-bulb temperatures at the SRP. The approach temperature is the number of degrees over the ambient wet-bulb temperature to which the reactor secondary cooling water can be reduced by the cooling tower. The curves on Figure 4-28 show the resultant cooled/cooling-water temperatures for the three approach temperatures. If the 1-percent worst-case meteorological condition (the 1-percent design wet-bulb temperature is 26.7°C) had been used to develop the curves, the resulting

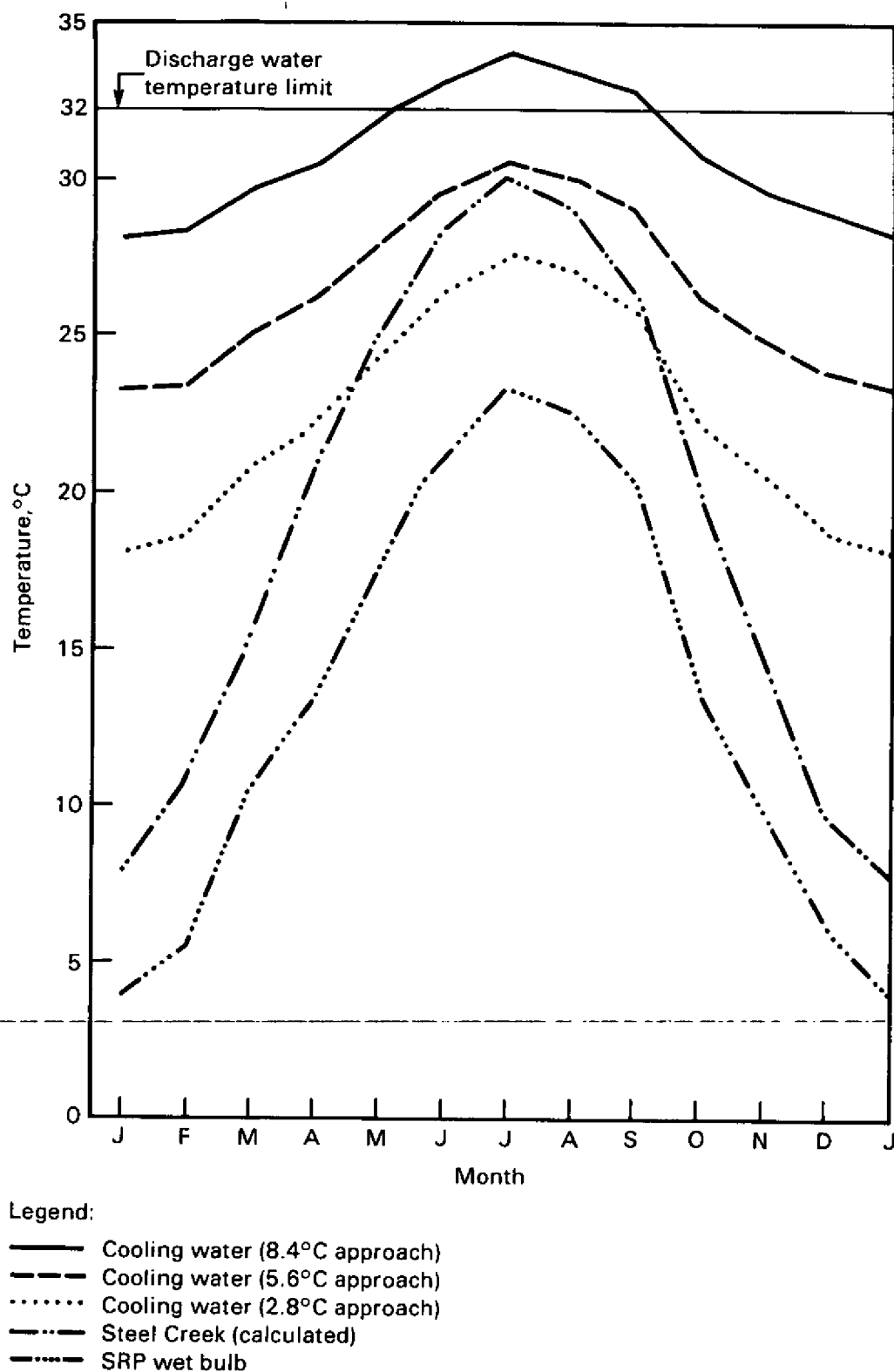


Figure 4-28. Average monthly wet-bulb temperature responses at SRP and cooling-tower water discharge temperatures.

cooling-tower discharge-water temperatures would have been higher by about 3.5°C than those shown. With the 1-percent design wet-bulb temperature, both the 5.6°C and the 8.4°C approach temperature towers would exceed the State of South Carolina water-discharge temperature limit of 32.2°C part of the time.

For commercial power plants, recirculating cooling towers have been constructed as fast as 18 months from award of contract. The temperature of the L-Reactor cooling water would be higher than that of commercial power plants, which would require special consideration in the engineering design of the cooling towers and pumps. Although the time period required for the design, procurement, construction, and testing of recirculating cooling towers and pumps for L-Reactor could be expedited, DOE does not believe that the 27-month schedule could be greatly shortened without sacrificing proper consideration of the operability and reliability of the recirculating cooling tower system.

4.4.2.3.1 Cooling towers--once through

4.4.2.3.1.1 Once-through--discharge to Steel Creek

Cooling towers could be added to L-Area that treat the heated effluent and discharge it directly to Steel Creek. Such towers could be constructed adjacent to the existing reactor discharge canal, as shown in Figure 4-29. A diversion valve box would be built onto the 904-L sump to route the reactor discharge water through 750 meters of new 2.5-meter diameter pipe to the new cooling towers. The tower location would be a relatively flat area just north of Steel Creek along the west side of the discharge canal. This location is about 21 meters lower than the L-Reactor area and 12 meters lower than the outlet of the 904-L sump. The discharge from the cooling towers would run through short pipes to the existing discharge canal and then into Steel Creek at the original discharge point.

The differences in elevation between the diversion valve box and the cooling-tower sprays would be sufficient to eliminate the need for pumps. This would result in a capital cost and time savings, an energy savings, and less dependence on the operation of mechanical equipment.

This alternative could meet the 32.2°C temperature criterion for water discharged to State waters. River water would be passed through the reactor heat exchangers and cooling towers and diverted to the outfall. Water withdrawal from the river would be about 11 cubic meters per second, the same quantity as that for the direct discharge case.

About 27 months would be required to design and construct this alternative. On an expedited schedule this alternative could be constructed in a little more than 1 year. If L-Reactor operation starts before the alternative is implemented, a shutdown of about 1 month would be required while the new cooling system is connected into existing facilities.

The capital cost for the 2.8°C approach tower would be approximately \$55 million; the cost of the 5.6°C approach tower would be \$50 million. Annual operating costs for the 2.8°C and 5.6°C approach tower designs would be \$5.5 million and \$5.4 million, respectively. The present worth of this alternative would be \$102 million for the 2.8°C approach tower and \$96 million for the 5.6°C approach tower. The annualized costs would be \$12 million and \$11.3 million,

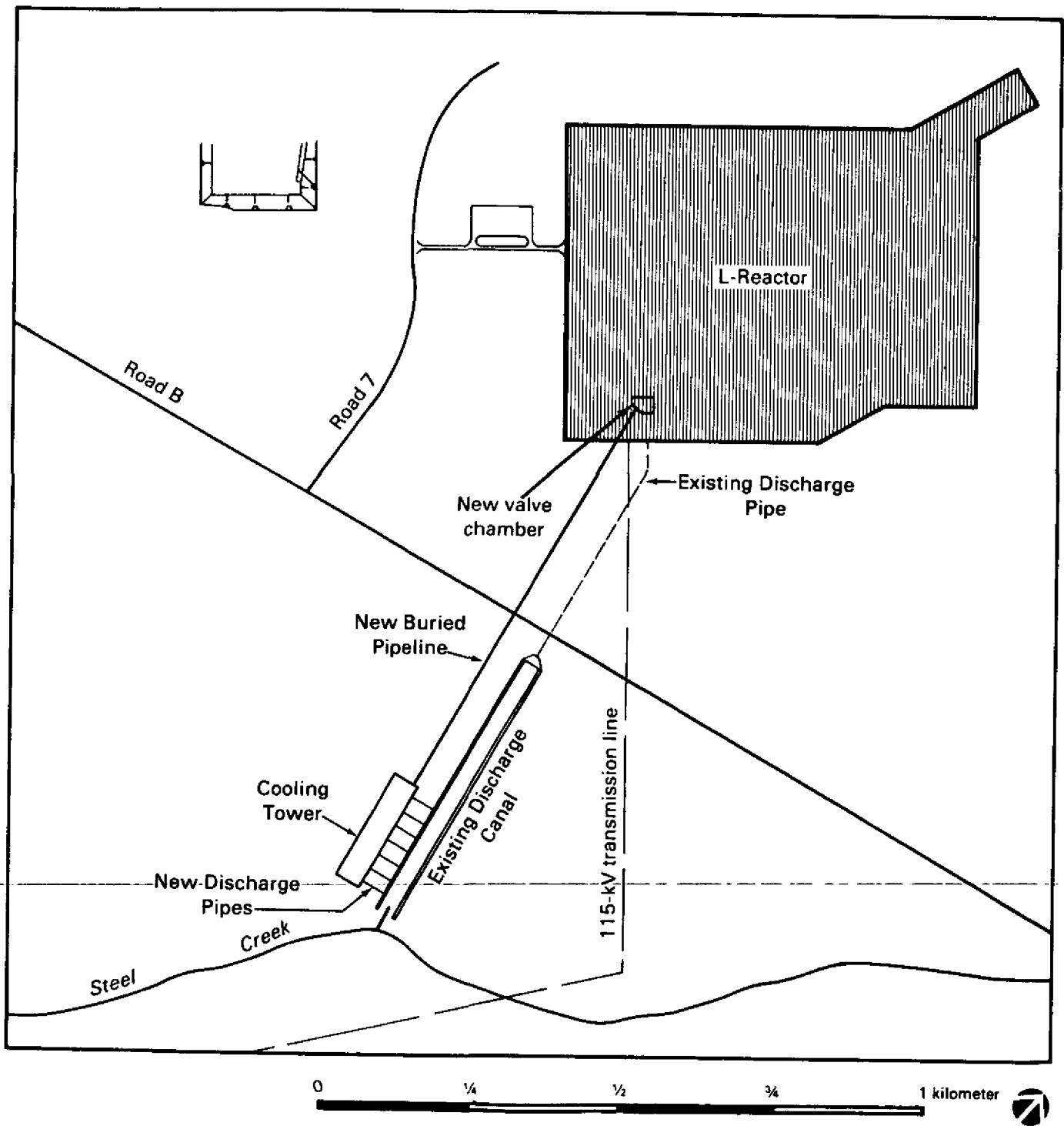


Figure 4-29. Conceptual layout of once-through cooling tower system.

respectively. An estimated 135 construction personnel would be required for either tower.

The production efficiency would be the same as that for the direct discharge alternative, 100 percent. The reactor would have a volume flow rate of about 11 cubic meters per second from the Savannah River. This alternative would discharge cooling effluent into Steel Creek at a flow of about 10.2 cubic meters per second.

The temperature of the effluent would be lower than that from the direct discharge alternative due to the cooling by the towers, and would vary according to the cooling tower approach temperature (i.e., 2.8° or 5.6°C).

With a 2.8°C approach temperature tower, the average effluent temperature entering Steel Creek would range from about 18°C in January to 28°C in July (Du Pont, 1983d). A preliminary analysis of SRP wet bulb data (Du Pont, 1983f) indicates the 32.2°C temperature maximum at the outfall would be exceeded once every 4.5 years. If the 5.6°C approach tower were used in this once-through system, the 32.2°C maximum at the outfall would be exceeded about five times a year. Downstream temperatures are listed in Tables 4-40 and 4-41, and shown (for the 2.8°C approach) in Figure 4-30. These temperatures assume no power reduction. Average ambient Steel Creek temperatures measured over a 30-year period at Road A are about 29°C in summer, 22°C in spring, and 8°C in winter.

Table 4-40. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (2.8°C approach)

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	28	27	23	18
Road A	29	28	23	17
Swamp at delta	30	28	23	15
Mid-swamp	29	27	21	13
Mouth of creek at river	29	27	21	13

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering Steel Creek.

Once-through cooling towers (either the 2.8°C or the 5.6°C approach temperature) with a discharge to Steel Creek would provide normal compliance with the 32.2°C maximum discharge temperature during average meteorological conditions.

The towers would substantially mitigate the thermal effects associated with direct discharge; the environmental impacts of this alternative would be

Table 4-41. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (5.6°C approach)

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	31	30	28	24
Road A	32	30	26	21
Swamp at delta	32	30	26	19
Mid-swamp	30	28	23	15
Mouth of creek at river	30	28	22	14

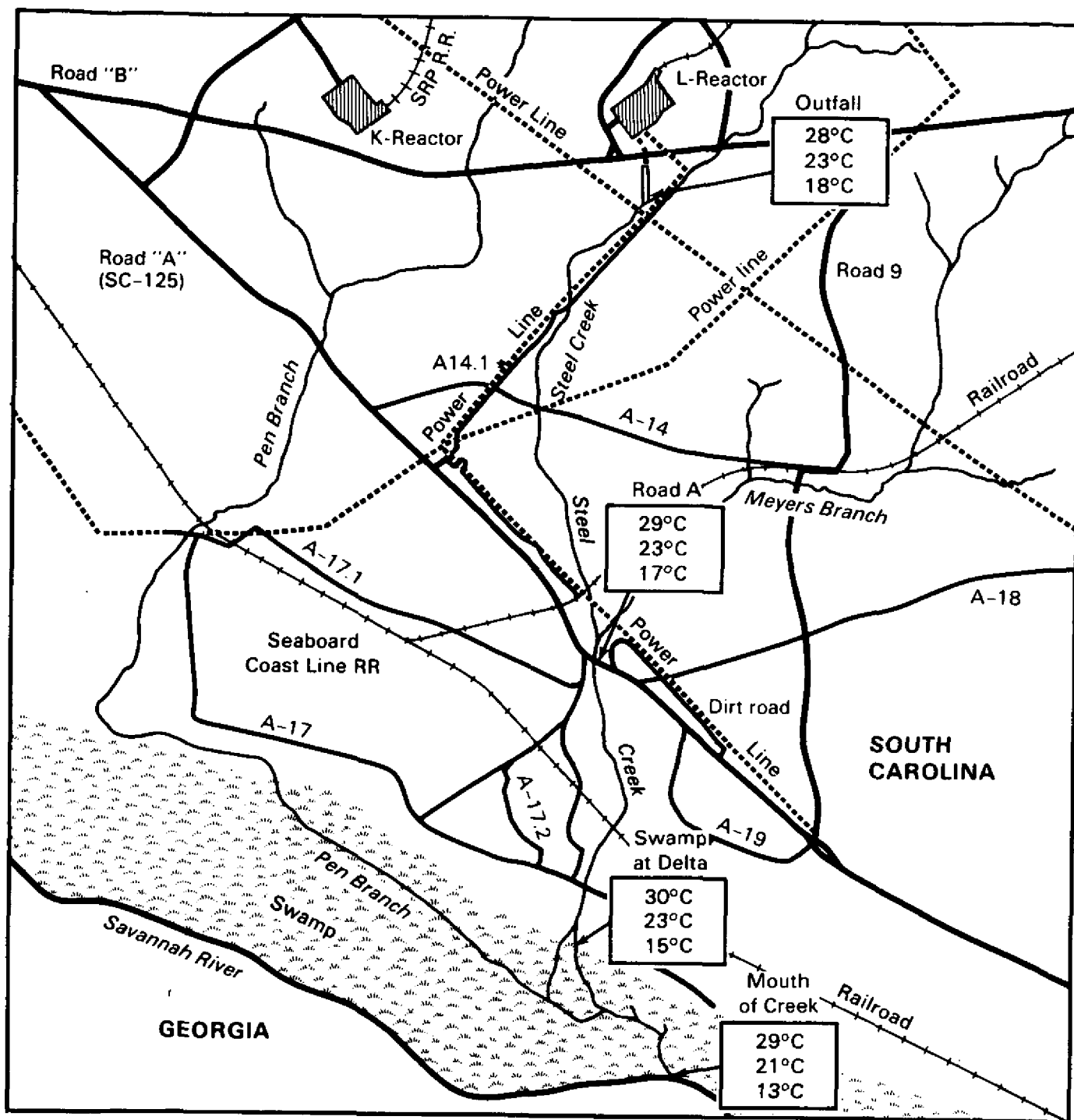
^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering Steel Creek.

somewhat less than those for direct discharge because of flow rate; they are summarized as follows:

- The high flow rate would eliminate between 420 and 580 acres of wetlands in the Steel Creek corridor. In addition, about 30 acres of uplands would be impacted by the construction of the cooling towers. Because the effluent would not have markedly elevated temperatures, the high flow rate would impact between 70 and 80 percent of the area predicted for direct discharge. Thus, between 215 and 335 acres of wetlands would be eliminated in the delta and swamp. The total amount of wetlands that would be impacted by this alternative is between 635 and 915 acres. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of in-kind habitat value" (USDOI, 1981).
- The spring water temperatures in mid-swamp would be within 4°C of ambient for the 5.6°C approach, and within 2°C of ambient for the 2.8°C approach. Thus, approximately 2500 acres of wetlands and aquatic habitat would be available to spawning riverine and anadromous fishes and other aquatic and semiaquatic biota.
- The impingement of 16 fish per day (5840 fish per year), and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.
- The remobilization and transport of 3.2 curies (2.8°C approach) or 3.3 curies (5.6°C approach) of radiocesium (first year). Liquid releases of tritium to the Savannah River would be about 8850 curies per year. These values would be about the same for both the 2.8°C and 5.6°C approach.



Legend:



Swamp

SUMMER
SPRING
WINTER

Seasonal creek temperatures
for this alternative

0 1000 2000 3000 4000 5000 meters



Figure 4-30. Steel Creek seasonal temperatures for cooling towers (2.8°C approach) once through.

- Fogging conditions (i.e., visibility is reduced to less than 1000 meters) would occur about 5 hours per year within 1.0 kilometer of the towers. Icing to an average thickness of 1.0 millimeter on horizontal surfaces within 0.5 kilometer of the towers would occur 55 hours per year. Salt drift deposition within 1 kilometer is estimated to be 0.37 kilogram per acre per month.
- Potential impacts to five archeological sites eligible for the National Register. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.
- No impacts to substrate, water quality, or water levels due to dredging and filling.

This alternative would require the following permits or processes: (1) an NPDES permit, (2) a 316(a) demonstration, (3) consultations with the FWS, and (4) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, environmental impacts would be as described above (i.e., loss of about 635 to 915 acres of wetlands due to flow effects). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.1.2 Once through--canal to swamp

Under this alternative, 2.8°C, 5.6°C, or 8.4°C approach cooling towers would be constructed on the south side of Road B, approximately 1000 meters southwest of L-Reactor, as shown in Figure 4-29. The cooling-water effluent would be pumped to the towers through a buried pipeline from a new sump constructed over the existing cooling-water discharge pipe. The sump, approximately 9 meters square and 11 meters deep with pumps, would be built over the existing outfall pipe.

As shown in Figure 4-31, the discharge from the cooling tower would flow into a new excavated and lined canal, which would be constructed along or near the top of the west bank of Steel Creek. The canal would be routed adjacent to Steel Creek above the floodplain and extend for approximately 10.4 kilometers before discharging at the delta. This canal, which would be similar to those constructed with Par Pond, would cross under two railroad tracks, roads A-14, A, A-17.1, and A-17.2, and several 115-kilovolt and super control and relay cable lines. The canal would have to feed into a pile-supported aerial pipeline or viaduct where it crosses a low area about 1200 meters below Road A. This pipe or viaduct would discharge back into a canal and continue to the edge of the swamp. A discharge structure would be constructed in the Savannah River swamp west of the Steel Creek delta with diffusers to control erosion and to mix the cooling-water discharge.

About 27 months would be required to design, construct, and permit this alternative. If L-Reactor is started operating before this alternative is constructed, a shutdown of about 1 month would be required while all new facilities

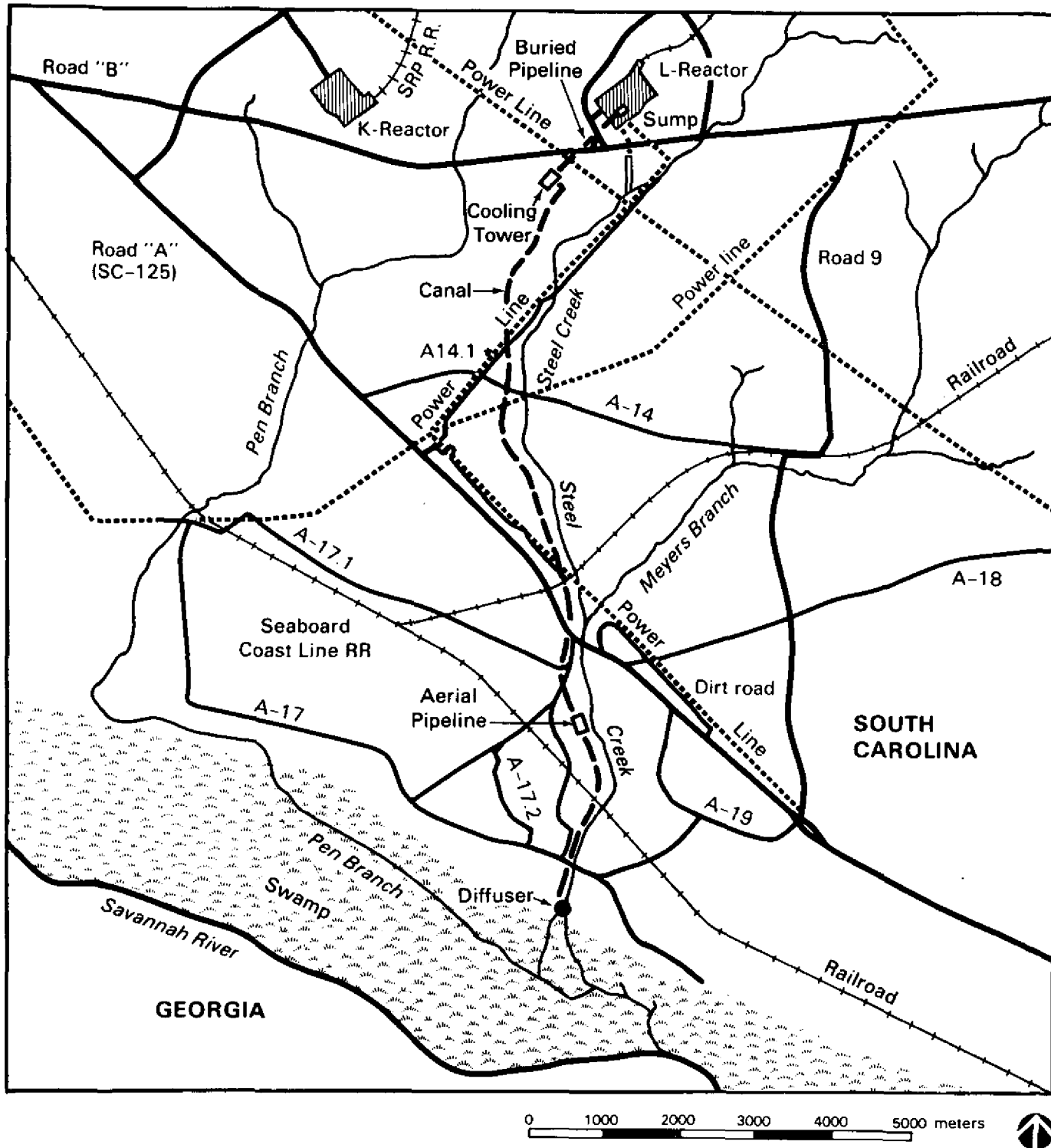


Figure 4-31. Conceptual layout of cooling tower with canal to swamp.

are completed to cut the existing pipe and install a valve to retain water in the sump.

Dredge material from the canal and the area in the swamp around the diffuser will be handled and monitored to meet applicable regulatory requirements. Thus, no significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or Savannah River due to dredge and fill activities. Access roads to construction areas would be selected to minimize impacts.

Capital costs for the pumping station, cooling towers, canal/pipeline, and other related items would be an estimated \$68 million to \$89 million, depending on cooling-tower efficiency. Annual operating costs would be an estimated \$5.2 million to \$5.6 million. The present worth of this alternative would be from about \$112 million to \$136 million, and the annualized cost would be \$13.2 million to \$16 million. An estimated 300 construction personnel would be required.

Production efficiency is estimated to be 100 percent of that for the direct discharge case. About 11 cubic meters per second of water would be required from the Savannah River. This alternative would discharge cooling-water effluent directly at the Steel Creek delta at a rate of flow of about 10.1 cubic meters per second.

These towers could be 2.8°C, 5.6°C, or 8.4°C approach temperature towers designed for about a 27°C wet bulb; however, only the cooling-water temperature from the 2.8°C tower would be near ambient when the water is discharged to the delta. Tables 4-42, 4-43, and 4-44 list seasonal temperatures for these three approach temperatures. Ambient temperatures (30-year average) in Steel Creek measured at Road A are 29°C in summer, 22°C in spring, and 8°C in winter.

Table 4-42. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (2.8°C approach)--
canal-to-swamp--

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	28	27	23	18
Swamp at delta	28	27	23	18
Mid-swamp	29	27	21	13
Mouth of creek at river	29	27	21	13

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering swamp.

Table 4-43. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (5.6°C approach)-- canal to swamp

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	31	30	28	24
Swamp at delta	31	30	28	24
Mid-swamp	30	26	23	15
Mouth of creek at river	30	25	22	14

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering swamp.

Table 4-44. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (8.4°C approach)-- canal to swamp

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	34	34	31	28
Swamp at delta	34	32	28	21
Mid-swamp	31	29	24	17
Mouth of creek at river	31	29	23	16

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering swamp.

The discharge at the swamp from the 2.8°C approach cooling tower would exceed State discharge temperature limits only infrequently. The 5.6°C and 8.4°C towers would be in compliance under average summer conditions. Under some conditions, power reduction would be necessary.

This alternative (all approach temperatures) would avoid Steel Creek to its delta, allowing approximately 420 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. About 30 acres of uplands would be impacted by construction of the towers. The effluent would reach the swamp via the canal parallel to Steel Creek and would enter the swamp through a diffuser at temperatures between 28° and 31°C during the summer; this would allow riverine and anadromous fish and other aquatic biota to have access to the swamp during the spawning season and partial access during the summer for the 2.8°C and 5.6°C approaches. However, the impacts on the swamp (i.e., loss of 215 to 335 acres of wetlands) from the 10.1-cubic-meter-per-second flow would be almost the same as those described for direct discharge. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOl, 1981). The canal would impact about 120 acres of upland pine forest and open fields, and require the disposal of approximately 850,000 cubic meters of spoil. Dredged material would be monitored and handled to meet applicable regulatory requirements.

This alternative would have no impact on endangered and threatened species that inhabit Steel Creek above its delta because the creek corridor would not receive thermal effluent. The discharge of 10.3 cubic meters per second through a diffuser located at the Steel Creek delta could channelize portions of the existing wetlands. However, the discharge temperatures (28°C and 31°C for 2.8°C and 5.6°C approaches in summer, respectively) would not have adverse impacts on the American alligator. The greatest potential impact would result from elevated water levels, which could eliminate foraging habitat for the endangered wood stork, and foraging and roosting habitat for migratory waterfowl. The shortnose sturgeon would be unaffected by this alternative.

The impacts of impingement and entrainment would be the same as those for direct discharge--impingement of 16 fish per day (5840 fish per year) and annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Under this alternative, there would be no remobilization or transport of radionuclides from the substrate of the Steel Creek corridor. Approximately 1.4 curies of radiocesium from the delta and swamp would be remobilized and discharged to the Savannah River. Liquid releases of tritium to the Savannah River would be about 8900 curies per year.

Approximately 5 hours per year of fogging would occur within 1.0 kilometer of the towers. The estimated frequency of ice accumulation on horizontal surfaces will be 55 hours per year. Drift deposition of salts is predicted to be about 0.37 kilogram per acre per month.

Several archeological sites occur near or along the canal route and could receive adverse impacts from construction activities. A mitigation plan would be developed and implemented prior to restart similar to that described under direct discharge.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit,

(4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above (successional recovery of 420 to 580 acres of wetland in Steel Creek corridor and losses of 215 to 335 acres in the swamp). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.1.3 Once through--spray canal and canal to swamp

A variation on the previously described once-through, canal-to-swamp alternative using 2.8°C or 5.6°C approach cooling towers would be to add a spray system to the canal; this would reduce the cooling-tower discharge temperature of the water by about 3°C in the summer. The discharge would comply with State discharge criteria for the 2.8°C and 5.6°C towers. The spray canal location and configuration would be as shown in Figure 4-21.

About 27 months would be required to design and construct this alternative. A shutdown of about 1 month would be required while all new facilities are completed and connected to the cooling-water discharge of the reactor. Truck routes to construction areas would be selected to minimize environmental impacts. If a 5.6°C approach tower were used for this alternative, most of the discharge water temperature reduction that was caused by the spray canal would be lost due to the less efficient cooling tower.

Capital costs for the 2.8°C approach cooling towers, spray canal, and canal or pipeline to the Steel Creek delta would be about \$98 million; annual maintenance and operating costs would be about \$5.5 million. The present worth of this alternative would be \$146 million, and the annualized cost would be \$17.1 million (Du Pont, 1983d).

The capital cost for a 5.6°C approach cooling tower with a spray canal and canal to the swamp would be about \$93 million. With annual maintenance and operating costs similar to those of the 2.8°C approach tower, the present worth would be \$139 million and the annualized cost would be \$16.4 million. An estimated 330 construction personnel would be required.

The production efficiency for this alternative would be the same as that for the direct discharge alternative, 100 percent. Production efficiency (reactor power) would be reduced in the summer when cooling-water temperatures from the Savannah River are elevated. This alternative would discharge cooling-water effluent into the swamp via a canal at a somewhat lower rate of flow (10.0 cubic meters per second) than direct discharge due to evaporation losses.

Downstream temperatures for this alternative are presented in Tables 4-45 and 4-46. Ambient temperatures in Steel Creek at the delta (30-year average) would be summer--33°C, spring--22°C, and winter--8°C.

Table 4-45. Temperatures (°C) downstream in Steel Creek with a once-through cooling tower (2.8°C approach)--spray canal and canal to swamp

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Swamp at delta	30	28	23	12
Mid-swamp	29	27	21	10
Mouth of creek at river	29	27	21	11

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

Table 4-46. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (5.6°C approach) with a spray canal and canal to the swamp.

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Swamp at delta	32	30	24	15
Mid-swamp	30	28	22	13
Mouth of creek at river	30	28	22	13

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

This alternative would include complete avoidance of Steel Creek down to the swamp, allowing approximately 450 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. The effluent would reach the swamp via a canal near Steel Creek and enter the swamp through a diffuser at a temperature of 23°C in spring (2.8°C approach). This would allow access to the swamp and Steel Creek by spawning riverine and anadromous fish and other aquatic biota. However, the impacts on the swamp from the 10.0-cubic-meter-per-second flow would be somewhat less than those described for direct discharge.

Both the 2.8°C and the 5.6°C approach-temperature cooling towers would result in full-time compliance with the 32.2°C State discharge temperature limit as the cooling water enters the swamp.

The environmental impacts of this alternative would be similar to those for cooling towers with a once-through discharge via a canal to the swamp. These impacts are summarized as follows:

- About 55 acres of wetlands and 55 acres of uplands would be impacted by construction of the spray canal. No impacts to wetlands would occur within the Steel Creek corridor, but the increased flow rate would eliminate between 215 and 335 acres of wetlands in the swamp. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).
- Approximately 120 acres of upland pine forest and open fields would be disturbed for construction of the canal; the towers would displace 30 acres of uplands. About 850,000 cubic meters of spoil would have to be removed and stored or utilized. Any dredged material would be monitored and handled to meet applicable regulatory standards.
- No impact to the American alligator and shortnose sturgeon would occur; foraging habitat of the endangered wood stork and roosting habitat for migratory waterfowl would receive adverse impacts from increased water levels.
- Approximately 16 fish per day (5480 fish per year) would be impinged, and 7.7×10^6 fish eggs and 11.9×10^6 fish larvae would be entrained annually.
- No remobilization or transport of radionuclides from the Steel Creek corridor would occur. About 1.0 curie of radiocesium would be remobilized and transported to the Savannah River by either approach. Liquid releases of tritium to the river would be about 8640 curies per year.
- Approximately 5 hours of fogging and 55 hours of horizontal icing would occur, and 0.37 kilogram per acre per month of salt drift would be deposited.
- Several archeological sites near or along the canal route could receive adverse impacts from construction activities. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.
- The bottom contour of the swamp near the diffuser would be modified.
- No impacts to water quality or increased suspended particulates and turbidity would result from the dredging of the canal. Short-term impacts could be associated with the installation of the diffuser.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.1.4 Once through--canal to swamp; pipe to river

Another variation of the once-through cooling-tower alternative would use the same canal to the swamp as that described previously, except it would not discharge near the Steel Creek delta. Instead, it would discharge into a pile-supported pipeline extending approximately 2500 meters across the swamp to a new discharge structure with diffusers to be constructed in the Savannah River below the mouth of Steel Creek. This alternative is shown in Figure 4-32. The effluent completely bypasses the Steel Creek corridor and swamp.

For this design, K-Reactor would still discharge through the mouth of Steel Creek, but L-Reactor would discharge downstream into the K-Reactor plume.

The canal would be parallel to the Steel Creek floodplain. It would be constructed by using material from cuts as fill material where needed. The pipeline across the swamp would be supported on pilings to prevent the pipe from acting as a water barrier when the swamp is flooded. Because a pile-driver would be used, no material would have to be dredged for the pilings. Barges would be floated in during periods of high water and tied together to form a working platform or temporary causeway. Equipment for building the pipeline would work from the barges. Vegetation adjacent to the pipeline would be removed to provide room for the barges. Some dredging and fill at the river would be needed to place the diffuser. The dredged material would be monitored and handled to meet applicable regulatory standards.

About 27 months would be required to design, construct, and permit this alternative. All construction would take place away from Steel Creek. A shut-down of about 1 month would be required while the new facilities are completed and connected to the cooling-water-discharge if L-Reactor operation starts before this alternative is implemented.

Temporary, limited impact to wetlands from this alternative would result from the construction of the pipeline. This raised structure would extend from a point near the Steel Creek delta to the Savannah River, a distance of 2500 meters. Pipeline construction could have adverse impacts on the Savannah River swamp because of: (1) piles driven into the substrate to support the pipeline, (2) the use of heavy equipment affecting wetlands by compacting the substrate, and (3) increased erosion and sedimentation due to disturbances of the substrate.

Capital costs for the cooling towers, the canal to the swamp, and the pipeline over the swamp to the river would be about \$103 million for the 8.4°C approach tower or \$112 million for the system with the 5.6°C approach tower. Yearly maintenance and operating costs would be \$5.2 million to \$5.4 million and the present worth would be \$140 million to \$158 million. Annualized cost would be \$16.5 million to \$18.6 million (Du Pont, 1983d). An estimated 375 construction personnel would be required.

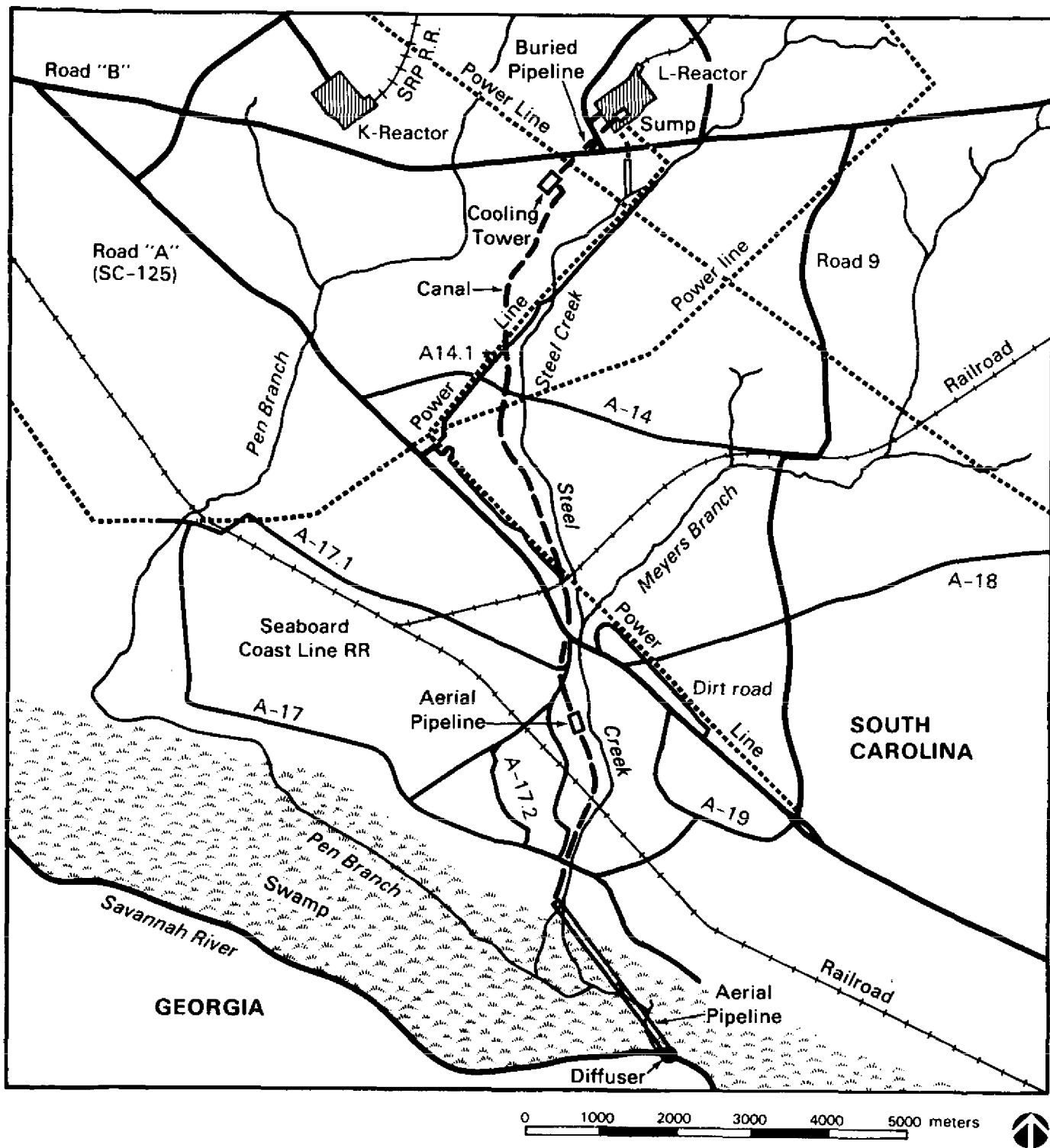


Figure 4-32. Conceptual layout of cooling tower with canal to swamp and pipeline to river.

The production efficiency for this alternative would be 100 percent, the same as that for the direct discharge alternative. Water withdrawal from the river would be the same as for direct discharge. The only environmental impact to the swamp would be due to the pipeline construction.

The water discharge flow rate to the Savannah River would be about 10.1 cubic meters per second for this alternative. No discharges would be released to Steel Creek.

Because this alternative would completely avoid Steel Creek and the swamp, approximately 730 to 1000 acres of wetland would continue to undergo successional recovery; fish would have full access to Steel Creek and the swamp. However, the access of fish to Boggy Gut Creek would be limited, especially during the spring and summer.

In summer, considering extreme meteorological conditions, this alternative would discharge effluent into the Savannah River at temperatures of 5°C and 7°C above ambient for the 5.6°C and 8.4°C approaches, respectively. In the spring, temperatures at the mouth of Steel Creek would be 5° to 7°C above ambient. Effluent temperatures in winter at this discharge point would be 19° to 21°C. These temperatures would be 7° to 9°C above ambient temperature. The 5.6°C approach alternative would comply with maximum discharge temperature criteria; the 8.4°C approach alternative would not comply.

The diffuser would be constructed to mix the effluent rapidly with the river. Based on seasonal outfall temperatures, a zone of passage would be maintained to allow movement of anadromous fish past SRP; the mouth of Steel Creek would not be blocked by temperatures high enough to exclude riverine and anadromous fish from entering and spawning in the Steel Creek swamp system (for both 5.6°C and 8.4°C approach temperatures). Discharge temperatures could attract some fish species into the thermal plume during the winter; however, insignificant impacts are expected on riverine species due to overwintering stress.

The pipeline would be constructed above the high-flood mark (about 7 to 9 meters), so it could not act as a dam and impede water flow during flooding.

Proper buffers would be installed during construction to prevent movement of suspended particulates, which could cause turbidity impacts. Discharge water quality would be the same as that described for direct discharge. No significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or the Savannah River.

Other environmental consequences of this alternative would be as follows:

- Construction of the canal would impact about 120 acres of upland pine forest and open fields, and would require the disposal of approximately 850,000 cubic meters of spoil material. The construction of the towers would impact 30 acres of upland pine forest.
- Construction of the pipeline would impact foraging habitat of the endangered wood stork.

- The impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae would occur.
- No remobilization and transport of radionuclides in sediments of Steel Creek and the swamp would occur. About 0.25 curie of radiocesium would be released annually from Steel Creek as the result of P-Area discharges and natural flow. Liquid releases of tritium to the Savannah River would be about 8900 curies per year.
- Atmospheric discharges from the canal and cooling towers would result in approximately 5 hours of increased fogging, 55 hours of icing on horizontal surfaces, and salt drift deposition of 0.37 kilogram per acre per month.
- Several archeological sites occur near or along the canal route and could receive adverse impacts from construction activities. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.2 Cooling towers--recirculation

4.4.2.3.2.1 Total recirculation--blowdown to Steel Creek

Cooling towers that completely recirculate the cooling water could be added to the L-Reactor site. The towers would be designed for a 2.8°C or 8.4°C approach temperature at a 27°C wet bulb. The secondary cooling water would be discharged from the reactor heat exchanger, cooled by the cooling towers, and returned to the 186-L reservoir for recirculation. Makeup water would be required to replace evaporative and blowdown losses.

This option would require the construction of cooling towers adjacent to the reactor (Figure 4-33). A reinforced concrete sump, approximately 9 meters square and 11 meters deep with pumps, would be built over the existing outfall pipe. The sump pit could be constructed around the existing outfall pipe while reactor flows continue. Discharge pipes from the pumps would run above ground to connections with an underground pipe that would convey the heated water to the top of the cooling towers. The flow would proceed by gravity to reinforced concrete basins beneath the towers and then to the 186-L reservoir. About 27 months would be required to design and construct this option (Du Pont, 1983f).

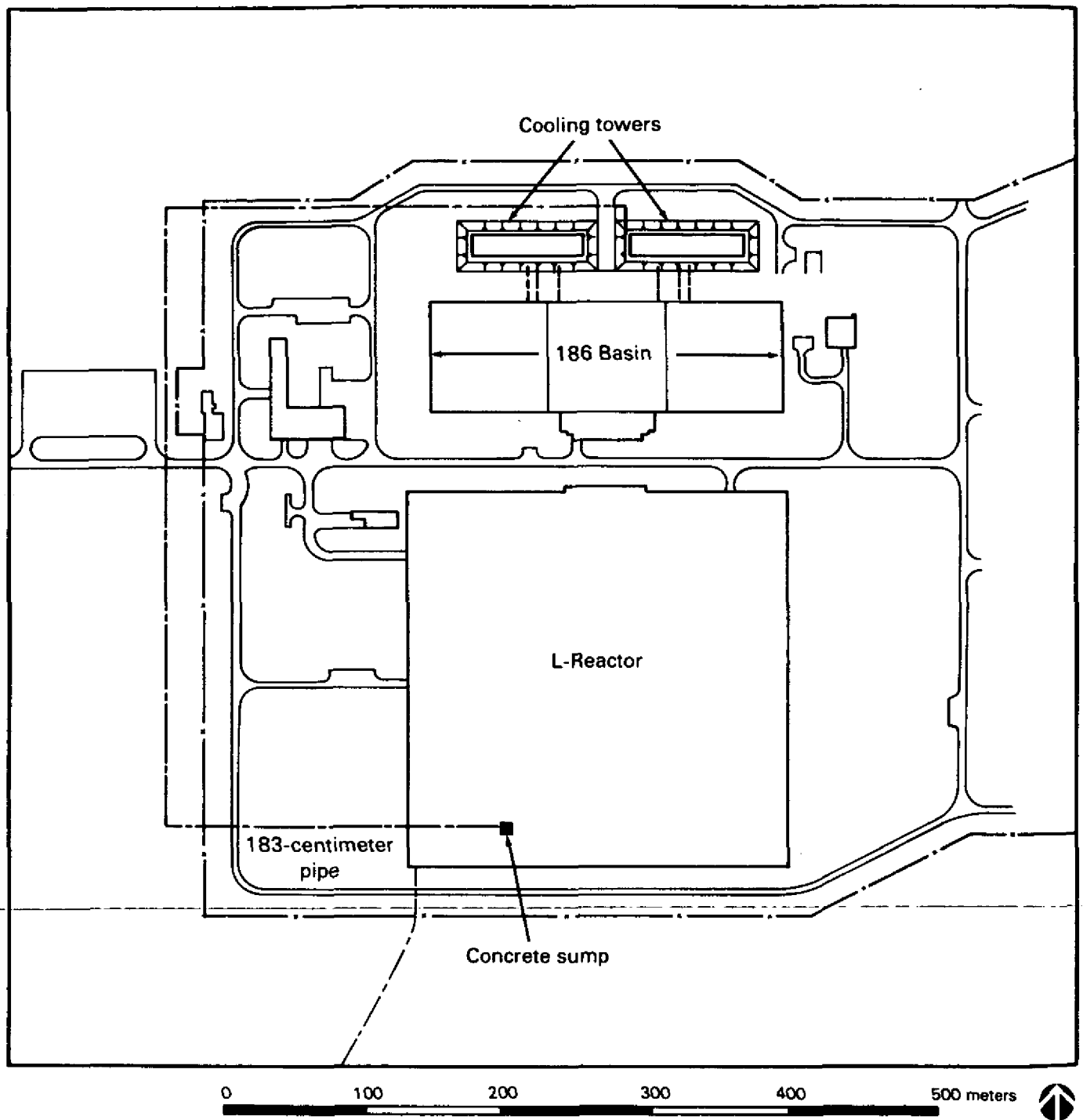


Figure 4-33. Conceptual design and location of mechanical draft cooling towers for L-Reactor.

All construction would take place away from Steel Creek. If L-Reactor is restarted before this alternative is implemented, a shutdown of about 1 month would be required to cut the existing pipe and install a valve to retain water in the sump.

Approximately 300 meters of the north perimeter fence and road would have to be relocated around the north side of the new cooling towers to provide space for the structures and the connecting pipes to the reservoir. A control building (approximately 8 by 15 meters) for miscellaneous electrical and mechanical items would also be required. Power could be run from existing sources in the L-Reactor complex to both new areas. Construction roads would be located to minimize environmental impacts.

Capital costs for the 2.8°C approach towers are estimated to be \$60 million. Annual operating and maintenance costs for the cooling towers would be \$2.5 million. The present worth would be \$142 million, and the annualized cost would be \$16.7 million. Towers designed for a 8.4°C approach temperature at a 27°C wet bulb would have a capital cost of about \$39 million, which is somewhat less than that for the 2.8°C approach temperature towers. Operating and maintenance costs would be \$2.2 million; the present worth would be \$198 million; and the annualized cost would be \$23.3 million (Du Pont, 1983d). An estimated 150 construction personnel would be required. The overall configuration of the cooling-tower water recirculation system would be similar to that shown for the more efficient towers in Figure 4-33.

Production efficiency for the 2.8°C approach towers is estimated to be 94 percent (derived from Du Pont, 1983d) of that for the direct discharge case. Production efficiency for the 8.4°C approach towers is estimated to be 85 percent (derived from Du Pont, 1983d). The makeup-water requirement for a 2.8°C or 8.4°C approach cooling tower is estimated to be approximately 1.4 cubic meters per second, of which about 0.6 cubic meter per second would be due to blowdown and about 0.8 cubic meter per second would be due to evaporation.

Under extreme meteorological conditions, the cooling-tower blowdown (0.6 cubic meter per second) to Steel Creek would have summer exit temperatures of 28°C (2.8°C approach) and 34°C (8.4°C approach).

The blowdown water discharge temperature from the cooling towers would vary depending on existing meteorological conditions and reactor operating power. Downstream temperatures are listed in Tables 4-47 and 4-48 and shown in Figures 4-34 and 4-35. The 30-year-average ambient Steel Creek temperatures measured at Road A are 29°C in summer, 22°C in spring, and 8°C in winter.

Under extreme summer meteorological conditions, the cooling-tower blowdown to Steel Creek would have an exit temperature of about 34°C (8.4°C approach). Near-ambient temperatures would be reached at the Steel Creek delta in the summer and spring for the 2.8°C approach. Temperatures at the delta in winter would be about ambient with the 2.8°C and 8.4°C approaches. Winter temperatures at the mouth of Steel Creek would be at ambient for both designs.

The 2.8°C approach tower would comply with the 32°C maximum discharge temperature except under extreme summer meteorological conditions. The 8.4°C approach system could be expected to regularly exceed the 32°C maximum temperature in summer.

Table 4-47. Temperatures (°C) downstream in Steel Creek with total recirculation cooling towers (2.8°C approach)

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	28	27	23	18
Road A	32	29	23	10
Swamp at delta	33	29	22	9
Mid-swamp	29	26	19	7
Mouth of creek at river ^d	30	27	21	12

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering Steel Creek.

^dTemperature increase due to mixing with K-Reactor effluent.

Table 4-48. Temperatures (°C) downstream in Steel Creek with total recirculation cooling towers (8.4°C approach)

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	34	34	31	28
Road A	33	30	24	12
Swamp at delta	33	29	23	10
Mid-swamp	29	26	19	7
Mouth of creek at river ^d	30	27	21	12

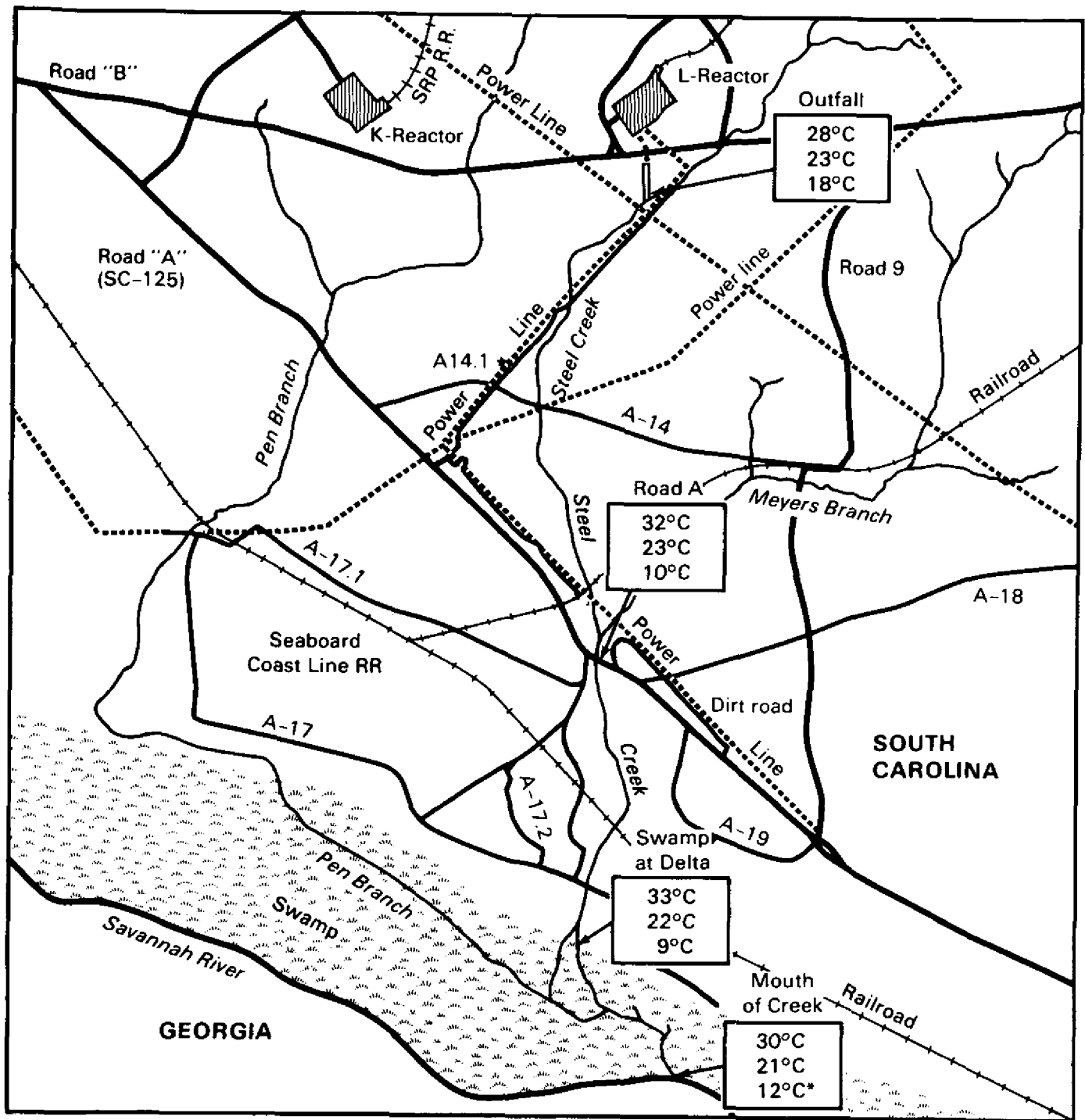
^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering Steel Creek.

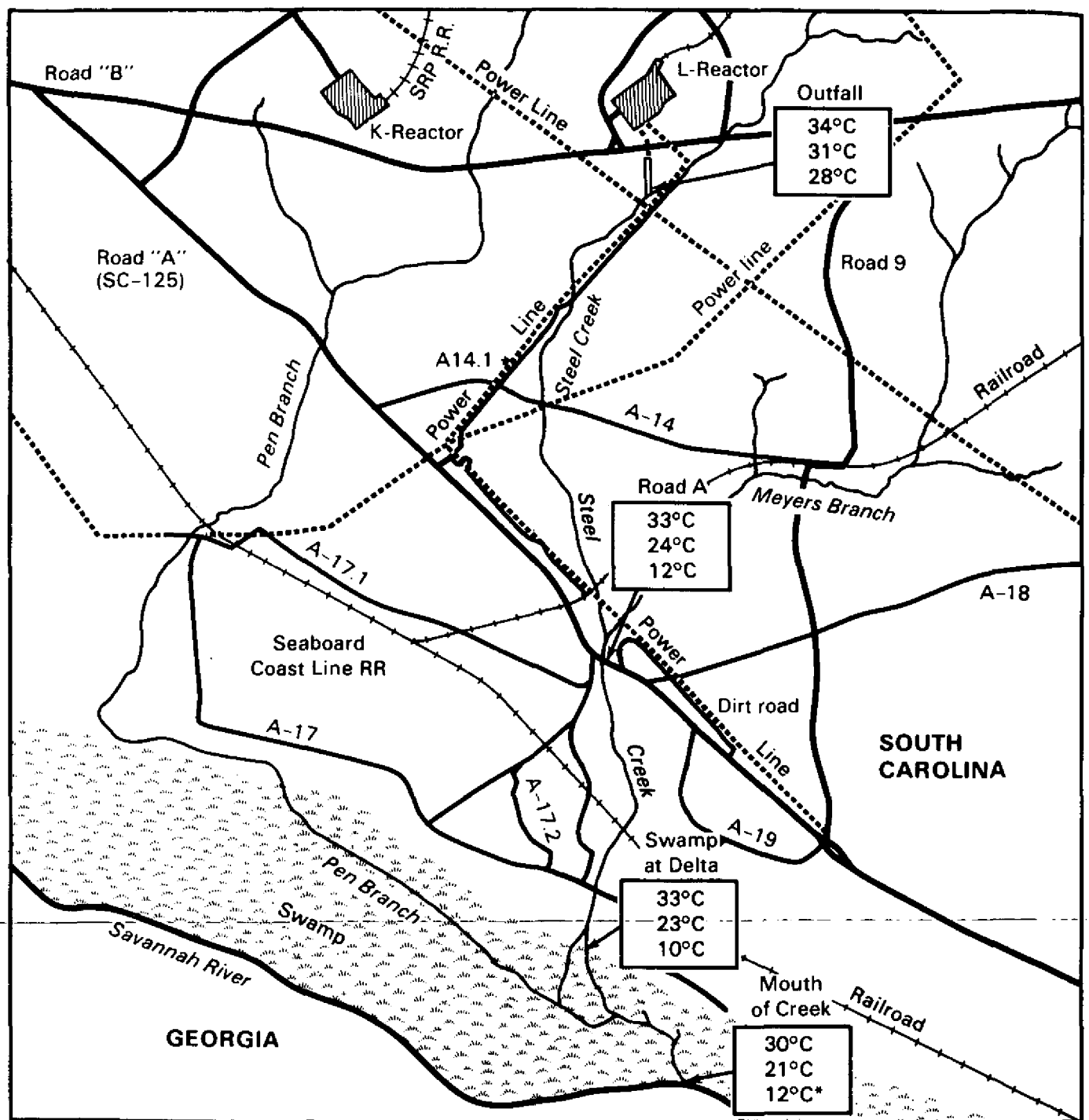
^dTemperature increase due to mixing with K-Reactor effluent.

The 2.8°C and 8.4°C approach recirculation alternatives would substantially reduce thermal discharge to Steel Creek, and would result in minimal impacts to the biota of the creek, its delta, the floodplain, and the Savannah River in comparison to the effects caused by direct discharge. This alternative would have low discharge rates, and impacts due to flow would be minimal.



*Increase due to mixing with K-Reactor effluent.

Figure 4-34. Steel Creek seasonal temperatures for cooling towers (2.8°C approach) with total recirculation.



Legend:



Swamp

SUMMER
SPRING
WINTER

Seasonal creek temperatures
for this alternative

0 1000 2000 3000 4000 5000 meters



*Increase due to mixing with K-Reactor effluent.

Figure 4-35. Steel Creek seasonal temperatures for cooling towers (8.4°C approach) with total recirculation.

The construction of the towers would affect approximately 30 acres of up-land pine forest. This area is contiguous with the L-Reactor facility and does not provide habitat for endangered or threatened species or other important wildlife.

Based on an estimated requirement of 7 percent makeup or 1.4 cubic meters per second of Savannah River water usage for the cooling towers, there would be approximately 743 fish impinged per year, and 9.8×10^5 fish eggs and 1.5×10^6 fish larvae entrained per year as the result of L-Reactor operation with cooling towers.

Radiocesium transport down Steel Creek would be about 0.8 curie per year by either approach. Liquid releases of tritium from L-Reactor to the Savannah River would be about 8900 curies per year.

Nonradioactive atmospheric releases would result in (1) a maximum of 5 hours per year of fogging (i.e., the visibility reduced to less than 1000 meters) within about 1 kilometer, and (2) a maximum of 55 hours per year of ice accumulation on horizontal surfaces. An estimated 0.37 kilogram per acre per month of salts would be deposited from tower drift within about 1 kilometer of the tower.

No archeological sites are expected to be impacted by this alternative.

The ion-concentration ratio in the blowdown to Steel Creek is expected to be about 3. Thus, the chemical constituents in the creek water near the L-Reactor outfall would be about 1.7 times their normal concentration without the blowdown. At Road A, the increases in concentration would be only about 1.4 times normal. The blowdown is not expected to have an appreciable impact on the water quality of Steel Creek, the swamp, or the Savannah River.

This alternative would require consultation with the FWS. No other consultations or permits are required.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the construction period.

4.4.2.3.2.2 Total recirculation--blowdown treatment

As indicated in Table 4-47 in Section 4.4.2.3.2.1, the resultant temperature rise in Steel Creek could exceed the State discharge criteria of 2.8°C above ambient due to reactor secondary cooling-water discharge temperatures during certain months of the year. Winter compliance would be the most difficult. Measures could be taken to ensure that the State requirements would always be met by additional blowdown treatment. Such measures could include one of the following: (1) refrigerating the blowdown before discharge to Steel Creek, (2) piping all the blowdown to Par Pond or K-Reactor and thereby eliminating

the blowdown discharge to Steel Creek, (3) using a small cooling tower to further reduce the blowdown temperature before discharge, or (4) using a holding pond for the blowdown with or without a spray system.

The application of a large refrigeration system (estimated 10,000 tons refrigeration capacity--see Figure 4-36) to cool the blowdown flow would guarantee full-time compliance with State discharge requirements, because the blowdown would always be discharged at near-ambient stream temperature. This alternative represents the "Best Technology Available" for minimizing thermal discharge impacts. Piping the blowdown to Par Pond or K-Reactor is being considered at this time with regard to its practical application. The small cooling tower or holding ponds could significantly reduce the discharge temperature, but possibly not enough to meet the 2.8°C criterion in the winter. Cost estimates are available at this time only for the refrigeration blowdown treatment.

Construction time and reactor downtime for this alternative have been estimated to be about the same as those for the total recirculation system without blowdown treatment (Section 4.4.2.3.2.1).

The capital cost of the total-recirculation 2.8°C approach cooling-tower system with blowdown refrigeration is estimated to be \$75 million. Yearly operating and maintenance costs for this alternative would be \$3.2 million. Present worth would be \$163 million and annualized cost would be \$19.1 million. An estimated 170 construction personnel would be required.

Although the refrigeration system would ensure compliance with State requirements, it would represent a significantly increased capital cost and annual operating cost over a cooling-tower system without blowdown treatment. Production efficiency would be 93.5 percent for this alternative with refrigeration.

This cooling-system alternative would discharge 0.6 cubic meter per second of blowdown effluent at the same temperatures in summer and spring as those achieved by cooling towers having total recirculation (2.8°C approach). In summer, winter, and spring, near-ambient temperatures (calculated) would be achieved from the outfall to the Savannah River. Winter temperatures at the mouth of Steel Creek would be 11°C. This slightly over-ambient-temperature water could attract and concentrate fish near the mouth of Steel Creek.

Table 4-49 lists Steel Creek temperatures for various seasons with this alternative. Ambient temperatures in Steel Creek at Road A are 29°C in the summer, 22°C in the spring, and 8°C in the winter.

The total-recirculation cooling towers with blowdown refrigeration would be in continuous compliance with the maximum 32°C discharge temperature except during extreme summer meteorological conditions. If less efficient cooling towers were used, additional refrigeration could be used to meet State requirements; cost, however, would increase accordingly. The refrigeration unit would be operated for a longer time period over the year if less efficient towers were used.

This alternative would have essentially the same environmental impacts as those resulting from the implementation of cooling towers having total recirculation (2.8°C approach) without blowdown cooling during the spring and summer

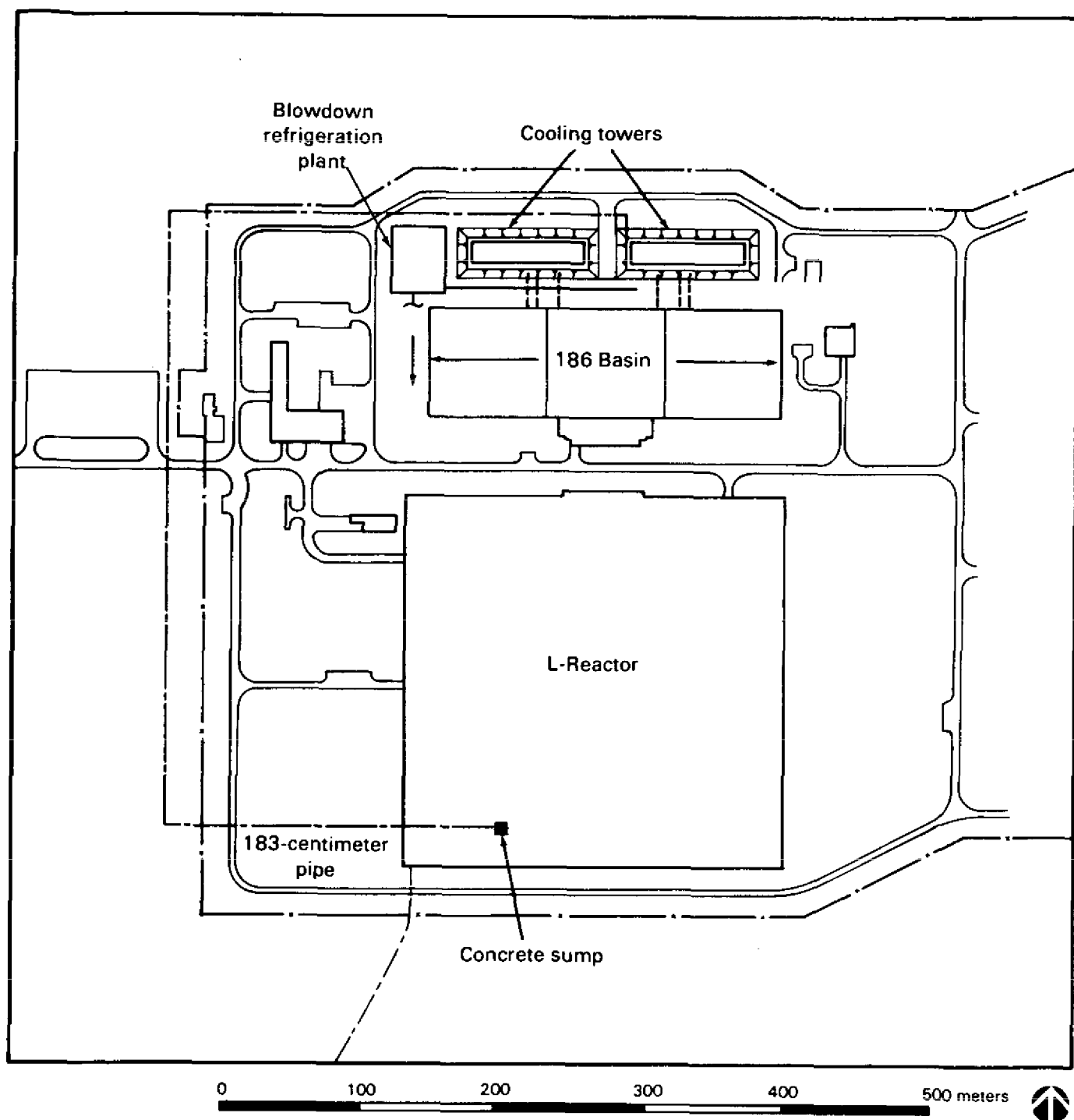


Figure 4-36. Conceptual design and location of recirculating cooling towers with blowdown refrigeration.

Table 4-49. Temperatures (°C) downstream in Steel Creek with a total-recirculation cooling tower (2.8°C approach) with blowdown treatment (refrigeration)

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	28	27	23	11
Road A	32	29	23	9
Swamp at delta	33	29	22	9
Mid-swamp	29	26	19	7
Mouth of creek at river ^d	30	27	21	11

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering Steel Creek.

^dTemperature increase due to mixing with K-Reactor effluent.

because the blowdown would meet criteria without treatment. During the winter the impacts would be less with treatment because the blowdown would be treated to meet criteria. These impacts are summarized as follows:

- Construction of the towers would affect approximately 30 acres of upland pine forest. There would be no impact to wetlands or the biota that inhabit the Steel Creek ecosystem and swamp.
- There would be no impact to endangered and threatened species.
- The makeup requirement would be about 1.4 cubic meters per second. Approximately 743 fish would be impinged annually; annual entrainment of fish eggs and larvae would be 9.8×10^5 and 1.5×10^6 , respectively.
- Transport of radiocesium would be maintained at its normal level, about 0.8 curie per year. Tritium discharges in liquid effluents would be about 8900 curies per year.
- Atmospheric releases would result in (1) a maximum of 5 hours per year of fogging (i.e., visibility reduced to less than 1000 meters) within 1.0 kilometer of the towers, and (2) a maximum of 55 hours per year of ice accumulation on horizontal surfaces. An estimated 0.37 kilogram per acre per month of salts would be emitted.
- No archeological sites would be impacted.

Because of the low discharge rate, little or no change in present erosion or sedimentation patterns is expected. There would be no impacts to aquatic substrate or water quality from dredging and filling activities, because they are not required.

This alternative would require consultation with the FWS. No other consultations or permits are required.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetlands). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.3 Cooling towers--partial recirculation

4.4.2.3.3.1 Partial recirculation--discharge to Steel Creek

Cooling towers (2.8°C or 8.4°C approach temperature) that only recirculate a portion of the cooling water could be added to the L-Reactor site. From April through October the towers would cool water on a once-through basis and discharge all the effluent directly to Steel Creek. Based on equilibrium temperature calculations for these months, the discharge to Steel Creek under normal weather conditions would continuously meet the 32.2°C/+2.8°C temperature criteria if a 2.8°C approach cooling tower is used. Equilibrium temperature calculations indicate that, from November through March (Du Pont, 1983d,e), a portion of the cooling water must be recirculated to the 186-Basin. Table 4-50 lists the percent of the cooling-water flow exiting the cooling tower that would be allowed to discharge into Steel Creek. The percent of direct river water flow indicated in Table 4-50 is the blending water that would be mixed with the cooling-tower discharge to meet the State +2.8°C temperature criteria.

Table 4-50. Cooling-water usage for cooling-tower system with partial recirculation (2.8°C approach temperature tower)

Month	Percent of cooling tower flow into creek (tower discharge)	Percent of river water diverted directly to Steel Creek (blending water)
November	34	66
December	12	88
January	22	78
February	46	54
March	74	26

This alternative would require the construction of cooling towers adjacent to the reactor (Figure 4-33) as described for the complete recirculation tower alternative. In addition, a diversion box and piping would be required to direct the cooling water to either Steel Creek or the 186-L reservoir. About 27 months would be required to design and construct this alternative. Construction would take place away from Steel Creek. A shutdown of about 1 month would be

required while all new facilities are completed if L-Reactor is operated before the construction of this alternative.

Capital costs for this alternative are an estimated to \$70 million (2.8°C approach), and annual operating costs are an estimated \$5.5 million. Present worth of this alternative would be about \$140 million and the annualized cost would be about \$16.4 million (Du Pont, 1983d). An estimated 150 construction personnel would be required.

Production efficiency is estimated to be about 97.5 percent of that for the direct discharge reference case. The values in Table 4-50 are based on daily average temperatures in Steel Creek. River water withdrawal requirements would be 100 percent of the discharge and evaporation flow rates. The discharge rate for this alternative would be 10.9 cubic meters per second.

Because of the potential need for blending with river water to meet State discharge criteria, cooling water at near-ambient temperatures would be discharged to Steel Creek. Table 4-51 and Figure 4-37 present the seasonal maximum downstream temperatures in Steel Creek. Thus, there would be no appreciable impacts on the temperatures of Steel Creek or Savannah River water from the cooling-tower discharges.

Table 4-51. Temperatures (°C) downstream in Steel Creek with cooling towers with partial recirculation (2.8°C approach)

Location	Summerna	Summerb	Springb	Winterb
Discharge temperaturec	28	27	23	11
Road A	29	28	23	11
Swamp at delta	30	28	23	10
Mid-swamp	29	27	21	9
Mouth of creek at river	29	27	21	10

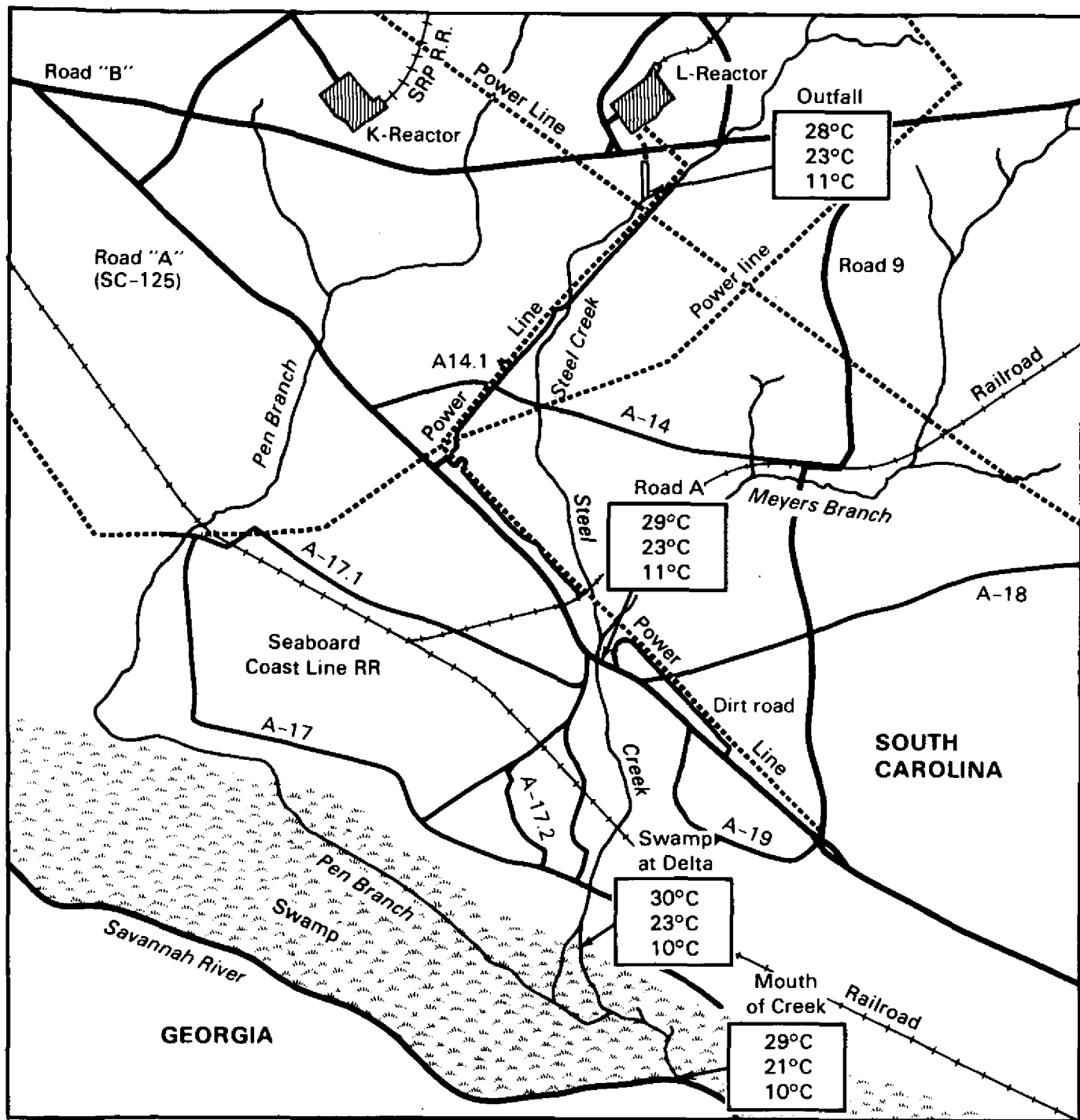
^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering Steel Creek.

The 2.8°C approach temperature tower would meet State discharge limits of 32.2°C at all times, as indicated in Table 4-51.

A cooling tower designed for an 8.4°C approach temperature would result in summer cooling-water discharge temperatures about 5°C higher than the 2.8°C approach temperature tower. Adding more than 5°C to Table 4-51 would result in noncompliance with State discharge limits.



Legend:



Swamp



Seasonal creek temperatures
for this alternative

0 1000 2000 3000 4000 5000 meters

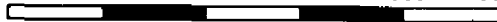


Figure 4-37. Steel Creek seasonal temperatures for cooling towers (2.8°C approach) with partial recirculation.

The 8.4°C approach temperature tower would also increase the blending water required, and would result in discharge rates that could significantly exceed 10.3 cubic meters per second if blending were to be applied during the summer months. The use of an 8.4°C approach temperature tower would be much less desirable, for these reasons, than a 2.8°C tower in this alternative. Because an 8.4°C approach tower in a partial recirculation system would not comply with State discharge requirements, even with flow rates greater than 11 cubic meters per second, it has been dropped from further consideration.

Partial-recirculation cooling towers would be in normal compliance with discharge criteria with infrequent excursions. These excursions are predicted to occur at night during January, February, and March, for 1 to 4 hours. Only the Steel Creek temperature rise criterion would be exceeded at these times (Du Pont, 1983d).

Because the duration and rate of discharge (10.9 cubic meters per second) for this alternative (2.8°C approach) are nearly identical to that for cooling towers with direct discharge (Section 4.4.2.3.1.1), the environmental impacts would be the same. Although near-ambient temperatures would be achieved from the outfall to the Savannah River, the effluent flow would have adverse effects on the environment. Emergent macrophytes and other wetland flora would be uprooted by the increased flow rate, and the delta would grow at a rate of about 3 surface acres per year. Summer and spring temperatures of Steel Creek above the delta would be about 1°C above ambient, and 3°C above ambient in winter. Water temperatures at the mouth of Steel Creek would be about ambient in summer and spring, and 2°C above ambient in winter. Thus, thermal effects to aquatic biota would not be significant.

Except for the mitigating effects associated with lower discharge temperatures, the environmental impacts caused by this alternative (2.8°C approach) would be similar to those for direct discharge; they are summarized as follows:

- The high flow rate would impact between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent would not have elevated temperatures, the high flow rate would impact between 70 to 80 percent of that area of the delta predicted for direct discharge. Thus, between 215 and 335 acres would be eliminated (or a total of 635 to 915 acres of wetlands). The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOI, 1981). The mitigation planning goal specifies that there be "no net loss of inkind habitat value." About 30 acres of uplands would be impacted for the construction of the cooling towers.
- Foraging sites for the endangered wood stork would be eliminated due to increased water levels.
- The impingement of 16 fish per day (5840 fish per year), and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae would occur.

- About 3.4 curies would be transported the first year using a 2.8°C approach; an 8.4°C approach would release 3.5 curies. Liquid releases of tritium to the Savannah River would be about 8800 curies per year.
- Atmospheric releases would result in (1) a maximum of 5 hours per year of fogging (i.e., visibility reduced to less than 1000 meters) within about 1.0 kilometer of the towers, and (2) a maximum of 55 hours per year of ice accumulation on horizontal surfaces. An estimated 0.37 kilogram per acre per month of salts would be emitted within about 1.0 kilometer of the towers.
- Potential impacts to five archeological sites eligible for the National Register. A mitigation plan would be developed and implemented prior to restart similar to that described under direct discharge.
- No impacts to substrate, water quality, or water levels due to dredging or filling.
- Increased sedimentation and erosion due to effluent discharge; delta growth is anticipated to be 3 surface acres per year.

This alternative would require the following permits or processes: (1) an NPDES permit, (2) consultations with the FWS, and (3) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (i.e., loss of 635 to 915 acres of wetlands). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.3.2 Partial recirculation--with refrigeration

This alternative is the same as the partial recirculation case described in Section 4.4.2.3.3.1 with the addition of a refrigeration unit that would be used primarily at night during the winter, to meet State discharge criteria. The refrigeration system would operate about 2 to 5 hours per night from January through March. During those hours, about 1 cubic meter per second would be diverted through the refrigeration unit to give a mixed Steel Creek temperature that complies with State discharge temperature requirements.

The estimated construction time would be 27 months, with a downtime of about 1 month for system connection, assuming L-Reactor would be operating before this alternative is implemented.

Capital costs would be about \$85 million, and maintenance and operating costs would be about \$5.7 million. Present worth would be \$157 million and annualized cost would be \$18.4 million (Du Pont, 1983d). An estimated 180 construction personnel would be required.

The production efficiency would be about 97.5 percent. Partial recirculation alternatives would discharge 10.9 cubic meters per second into Steel Creek, and total recirculation alternatives discharge only about 0.6 cubic meter per second.

Average ambient temperatures at Road A in Steel Creek are 29°C in summer, 22°C in spring, and 8°C in winter (Du Pont, 1983d). Table 4-52 lists downstream temperatures by season.

Table 4-52. Temperatures (°C) downstream in Steel Creek with partial recirculation with refrigeration (2.8°C approach)

Location	Summer ^a	Summer ^b	Spring ^b	Winter ^b
Discharge temperature ^c	28	27	23	11
Road A	29	28	23	11
Swamp at delta	30	28	23	10
Mid-swamp	29	27	21	9
Mouth of creek at river	29	27	21	10

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

^bBased on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^cTemperature of water entering Steel Creek.

Using a 2.8°C approach tower and a refrigeration unit, near-ambient creek temperature would be achieved continuously. Partial recirculation cooling towers (2.8°C approach) with refrigeration would, therefore, meet State discharge requirements, continuously.

Cooling towers with partial recirculation and refrigeration (2.8°C approach) would have thermal consequences that are similar to those from cooling towers with total recirculation and refrigeration (2.8°C approach). Thus, the environmental effects of this alternative would be essentially the same as those of the partial recirculation alternative without refrigeration. In general, environmental effects are summarized as follows:

- The high flow rate would impact between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent would not have markedly elevated temperatures, high flow rate would impact between 70 to 80 percent of that area predicted for direct discharge. Thus, between 215 and 335 acres would be impacted (or a total of 635 to 915 acres of wetlands). The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The

mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOl, 1981). About 30 acres of uplands would be impacted for the construction of the cooling towers.

- Foraging sites for the endangered wood stork would be eliminated due to increased water levels.
- The impingement of 16 fish per day (5840 fish per year), would occur, as would the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.
- The transport of 3.4 curies of radiocesium would occur the first year using a 2.8°C approach. Liquid releases of tritium to the Savannah River would be about 8800 curies per year.
- Nonradioactive atmospheric releases would result in (1) a maximum of 5 hours per year of fogging (i.e., visibility reduced to less than 1000 meters) within about 1.0 kilometer of the towers, and (2) a maximum of 55 hours per year of ice accumulation on horizontal surfaces. An estimated 0.37 kilogram per acre per month of salts would be emitted within 1.0 kilometer of the towers.
- Potential impacts to five archeological sites eligible for the National Register. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.
- No impacts to substrate, water quality, or water levels due to dredging or filling.

Impacts to wetlands from this alternative would be the same as those for partial recirculation without refrigeration. High flow would affect between 420 and 580 acres in the Steel Creek corridor, and between 215 and 335 acres of wetlands in the delta and swamp.

This alternative would require the following permits or processes: (1) an NPDES permit, (2) consultations with the FWS, and (3) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above (i.e., loss of 635 to 915 acres of wetlands). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.4 Other recirculation alternatives

Four alternative cooling systems were evaluated that would recirculate cooling water through impoundments located on the SRP. Impoundments that would require new design and construction include L-Pond, the High-Level Pond, and

Kal Pond. Par Pond, an existing impoundment that is currently used to cool P-Reactor, could also be used to cool L-Reactor.

DOE would perform safety analyses for the design of the cooling-lake embankment to ensure stability during construction, closure, filling, drawdown, and under all conditions of lake operation, including appropriate earthquake loading. The design will also assure that the embankment is safe against overtopping during the inflow of the design flood and during wave action. These analyses will be performed to ensure public safety, because a failure of the cooling-lake dam could have adverse impacts on portions of the Seaboard Coast Line Railroad and South Carolina Highway 125 (SRP Road A) where they cross Steel Creek or other onsite streams below a cooling lake.

Impounded water for a cooling lake would cause a local ground-water mound in the water-table aquifer. This effect of the lake would dissipate with depth and is expected to have only a small effect on water levels in the McBean Formation. The green clay is an important confining unit separating the McBean from the underlying Congaree Formation. It would prevent the increased head associated with a cooling lake from impacting the head differential between the Tuscaloosa and Congaree Formations (see Figure 3-9). It is also an important barrier to the migration of contaminants from near the surface to lower hydrostratigraphic units. In the Separations Areas, the green clay (about 2 meters thick) supports a head difference of about 24 meters between the McBean and Congaree Formations. Based on water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin, the green clay has effectively protected the Congaree ground water from contamination seeping into the ground (Marine, 1965). In the L-Area, the green clay is about 7 meters thick. At the Par Pond pumphouse along the strike of the McBean and Congaree Formations, the green clay also supports a large head difference; the water pumped from the Congaree Formation shows no evidence of tritium contamination even though tritium concentrations in that lake were measured at 27,000 picocuries per liter. Water pumped from the Congaree by the pumphouse well exhibited tritium concentrations of 170 picocuries per liter or less in comparison to concentrations of 260 ± 60 picocuries per liter in offsite well water (Ashley and Zeigler, 1981).

4.4.2.4.1 L-Pond

The damming of Steel Creek to form a lake, L-Pond, to accept heated effluent from L-Reactor has been investigated. The discharge from L-Reactor would enter L-Pond directly without any precooling. Cooled water from the lake would be pumped back to the L-Reactor reservoir for recirculation through the reactor.

Under this alternative, an earthen embankment would be constructed across Steel Creek approximately 750 meters above the Seaboard Coast Line Railroad bridge (Figure 4-38). This embankment would be approximately 32 meters high and about 1500 meters long, impounding just over 1300 acres, with a normal pool elevation of 61 meters above mean sea level. The total amount of earth fill required to construct the embankment would be 840,000 cubic meters. Several earthen berms would be required to prevent high water from overflowing natural saddles near the east and north ends of the lake.

The creation of L-Pond would require the relocation of two 115-kilovolt electric transmission and buried supervisor control and relay cable lines that cross Steel Creek near Road A-14. Approximately 1400 meters of South Carolina

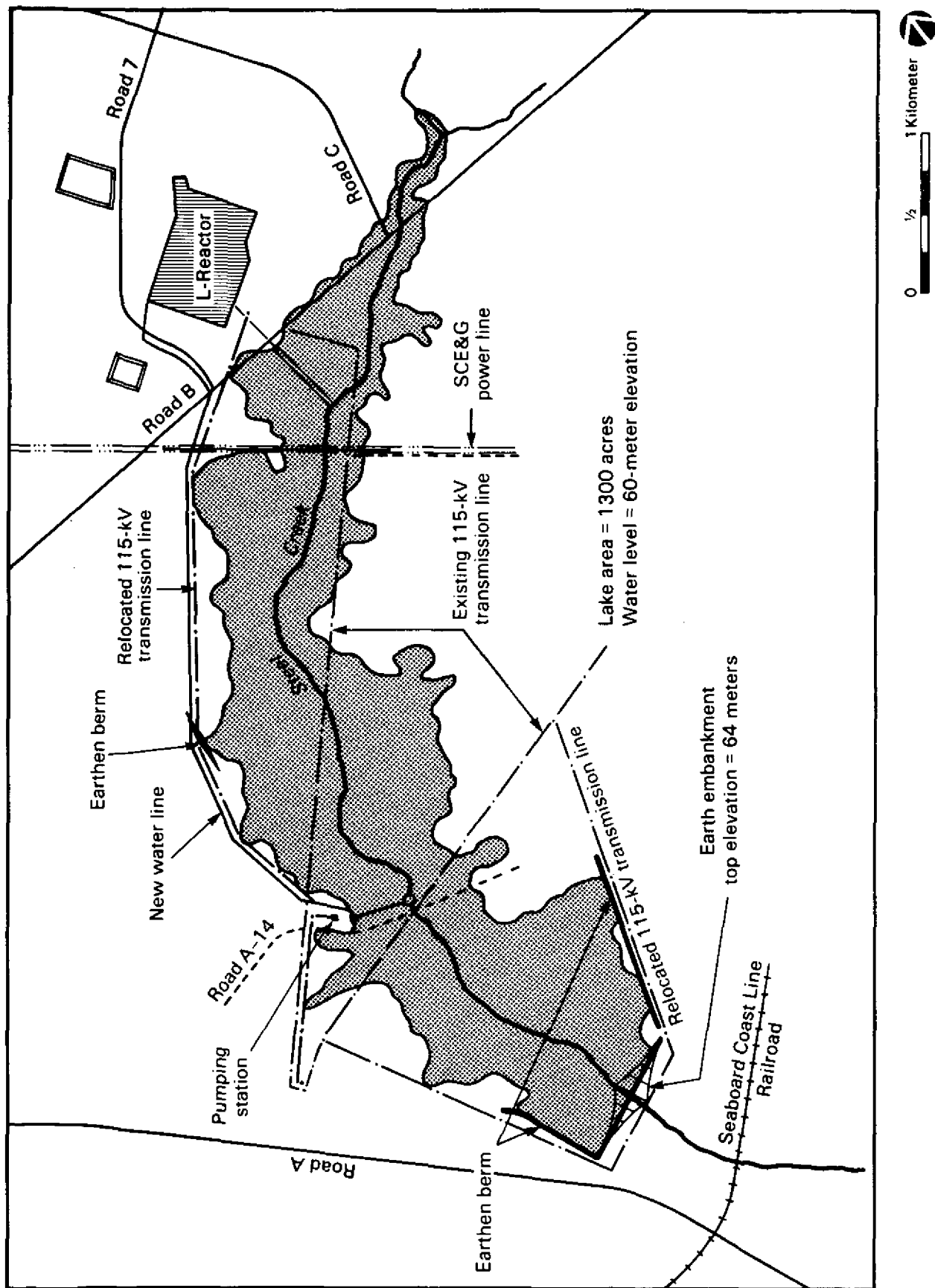


Figure 4-38. Conceptual design for L-Pond.

Electric and Gas Company 115-kilovolt transmission line would be replaced by steel towers and new conductor cable to enable the line to span the widened waterway. Several SRP roads inundated by the lake would be abandoned or raised.

A new pumping station, similar to but smaller than the existing Par Pond station, would be constructed on the northwest shore of the lake near Road A-14. The power for this station would be run from the existing 504-3G substation approximately 1200 meters away. A new pipeline generally paralleling the northwest shore of the pond would carry cooled water back to the L-Reactor reservoir. Access roads for construction activities would be routed to minimize environmental impacts. About 40 months would be required to design and construct this alternative (Du Pont, 1983d).

This alternative is similar to the 500-acre lake, except the dam and lake are larger. The construction of the recirculation portion would not affect reactor operation. A shutdown of about 1 month would be required to divert the stream through the discharge structure.

The estimated capital costs for L-Pond would be \$73 million, with annual operating expenses of \$2.9 million. The present worth would be \$135 million and the annualized cost would be \$15.9 million (Du Pont, 1983d). An estimated 630 construction personnel would be required.

The relative production efficiency of this alternative is expected to be 96 percent of that for the direct discharge option. The water discharge rate to Steel Creek would be about 0.5 cubic meter per second and would consist of the overflow from L-Pond. Makeup water temperatures from the Savannah River to L-Pond would have minor effects on L-Pond temperature and reactor operation.

Under extreme summer meteorological conditions, the overflow to Steel Creek would have an exit temperature of about 33°C, which is 2°C above ambient in summer at Road A. Near-ambient temperatures should be reached at the Steel Creek delta in the spring and summer. Thus, this alternative would not increase the water temperatures of the Savannah River.

The thermal behavior of L-Pond is expected to be similar to that of Par Pond. L-Pond should experience thermal stratification from April through October and it should be well mixed from November through March. During periods of thermal stratification, the hypolimnion could become intensely anoxic, with ferrous iron and other metals being dissolved from the sediment (Marshall and LeRoy, 1971). Seasonal cycling of cesium-137, similar to that found in Par Pond (Alberts et al., 1979), is probable in L-Pond.

This alternative would provide normal compliance with the maximum 32.2°C discharge temperature limit rise in Steel Creek except during extreme summer meteorological conditions.

Near-ambient temperatures would be reached at the Steel Creek delta, allowing continuing successional recovery of the swamp with associated utilization by aquatic and terrestrial species (fish, waterfowl, wood stork, and the American alligator). Delta growth under this alternative is expected to be near zero.

The L-Pond alternative would inundate approximately 1060 acres of upland pine. This lake would support minimal aquatic life because of a continually

high water temperature. Isolated cool-water refuges might be utilized minimally by aquatic (fish) and semiaquatic (herpetofauna, wading birds, beaver) biota.

This alternative would inundate approximately 7.6 kilometers of Steel Creek from just north of Road B to the dam (Figure 4-38). Thus, about 240 acres of wetlands including active habitat of the American alligator would be inundated. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOI, 1981). The mitigation planning goal specifies that there be "no net loss of inkind habitat value." If releases from L-Pond into Steel Creek are maintained near the average natural flow (i.e., 0.6 cubic meter per second), foraging habitat of the endangered wood stork would not be affected. Additionally, this option would have no impact on the shortnose sturgeon.

The makeup water required for L-Pond would represent a 9-percent increase (1.8 cubic meters per second) over present SRP intake withdrawal rates from the Savannah River. This increase would result in impingement and entrainment losses from the river of about 956 additional fish per year and 1.3×10^6 fish eggs and 1.9×10^6 fish larvae per year, respectively.

The transport of radiocesium off the site is expected to amount to about 0.8 curie per year, about half the amount presently transported (Hayes, 1981). Approximately 24 curies of the cesium-137 currently in the Steel Creek channel and floodplain would lie beneath L-Pond. This alternative would release 2170 curies per year of tritium from L-Reactor to the Savannah River.

Nonradioactive atmospheric releases would result in a maximum of 130 hours per year of reduced visibility (less than 0.8 kilometer) on the leeward side of the impoundment, and a maximum of 115 hours per year of ice accumulation on horizontal surfaces. No deposition of salts due to drift is expected.

The area subject to impact by this alternative contains 10 archeological sites. Two to four sites could be inundated. A mitigation plan would be developed and implemented prior to restart similar to that described under direct discharge.

The inundation of 1300 acres would modify the bottom contours of the substrate and create vastly different patterns in water circulation, depth (32 meters at the dam), and temperature. The diversity and abundance of benthic organisms would also be markedly changed. Excavation of the creekbed for dam construction would necessitate the disposal of approximately 3000 cubic meters of possibly contaminated spoil. The overflow from L-Pond, which would be discharged into Steel Creek, would have a minimal impact on the substrate of the creek or its delta.

Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the jurisdictional wetlands upstream of the embankment, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All uncontaminated material would be removed and used for backfill in the borrow areas. Thus, any impacts

on water quality and turbidity in the L-Pond would be temporary until suspended particulates settle and bottom sediments stabilize. Seasonal cycling of any remaining cesium-137 is probable in L-Pond (Alberts et al., 1979). The water quality of L-Pond should be very similar to that of Par Pond. An ion-concentration ratio (lake-to-river) of 1.0 to 2.5 is expected for L-Pond. Necessary precautions would be taken during embankment construction to contain suspended particulates and sediment from moving into the Steel Creek corridor. Embankment construction and L-Pond overflow is expected to have a minimal impact in water quality and turbidity in Steel Creek and the swamp.

L-Pond construction would vastly alter water levels and circulation patterns over the 1300 acres. Erosion control and removal of the excavated material would minimize the discharge of material that could obstruct or change the direction or velocity of flows both above the embankment and in Steel Creek below the embankment. The small increase in water levels below the embankment should have minimal impact on Steel Creek and the swamp.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 for once-through direct discharge (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from this alternative are that the Steel Creek ecosystem and swamp below the L-Pond dam would not be impacted. This would not begin until the end of the 40-month construction period.

4.4.2.4.2 Kal Pond

The feasibility of creating Kal Pond, which would serve both K- and L-Reactors, has been studied. Such a lake would not only mitigate thermal impacts associated with a direct discharge to Steel Creek by L-Reactor, it would also mitigate thermal impacts of K-Reactor on Indian Grave Branch and Pen Branch. Heated effluent from both reactors would enter Kal Pond; after natural cooling, it would be pumped back to the reactors for recirculation.

One large 2620-acre lake would be created by constructing embankments across both Steel Creek and Pen Branch (Figure 4-39). The Pen Branch embankment would be approximately 750 meters above Road A and the Steel Creek embankment would be about 300 meters above Road A-14. The location of the embankment on Steel Creek would eliminate any impact on one of the two 115-kilovolt transmission and control cable lines mentioned for L-Pond. It would also allow Road A-14 to remain undisturbed and would reduce the maximum height of the Steel Creek embankment by about 5 meters. The Pen Branch embankment would be approximately 800 meters long and the Steel Creek embankment would extend about 1400 meters. About 900,000 cubic meters of fill would be required to construct the two embankments. The normal water-surface elevation would be about 64 meters. This water level would necessitate raising, rerouting, or abandoning several SRP roads. Access roads for construction activities would be routed to minimize environmental impacts.

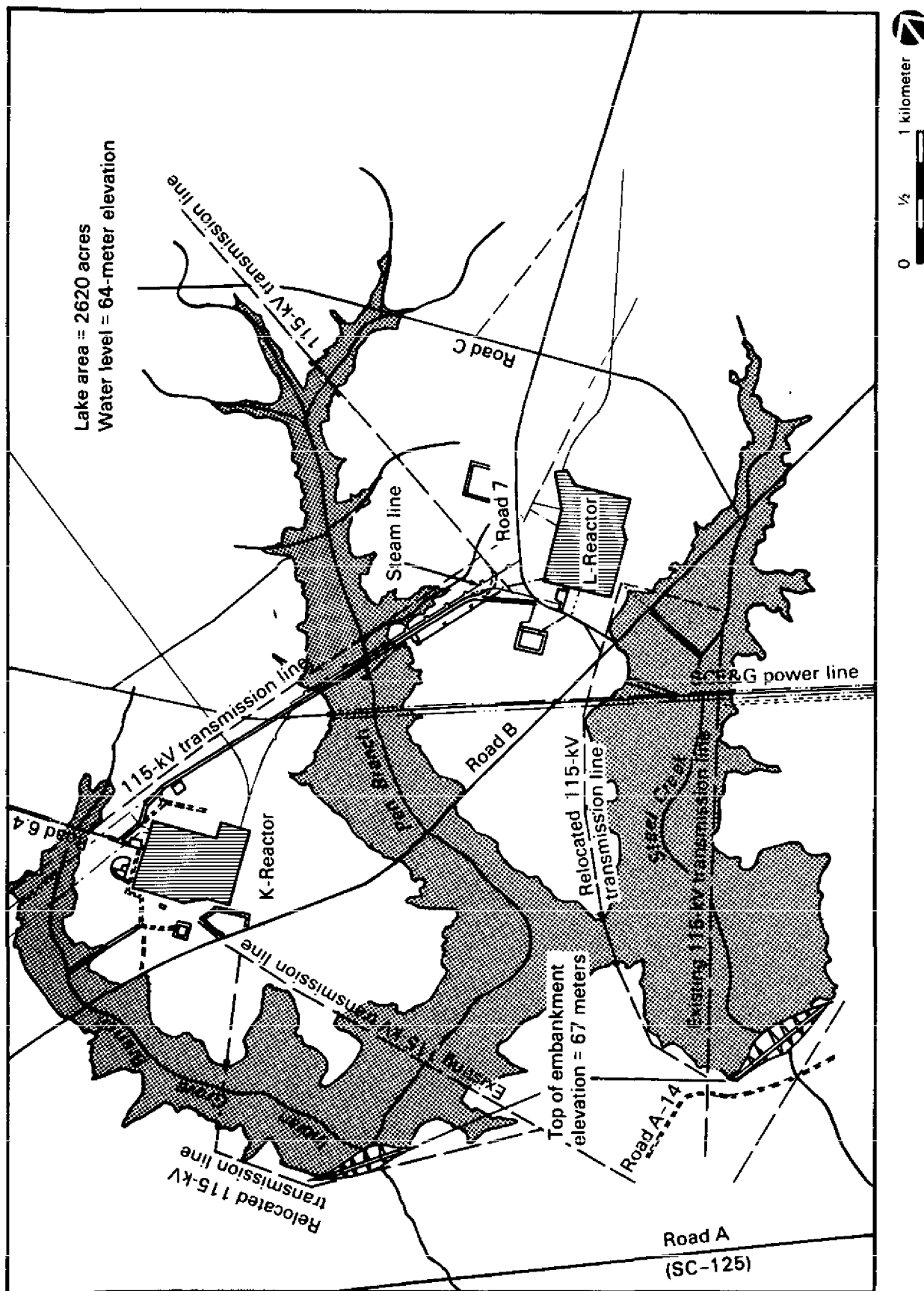


Figure 4-39. Conceptual design for Kal Pond.

A new outlet structure would be constructed at the edge of the new lake north of the abandoned section of Road B. Few modifications would be required at the K-Reactor discharge because the present canal extends above the elevation of the proposed water level.

Some modifications would have to be made to the K-Area-to-L-Area steam line and the river water lines serving K-, L-, and P-Reactors because Kal Pond would flood the areas where they cross Indian Grave Branch and Pen Branch.

Two 115-kilovolt transmission lines and control cables would have to be re-located, one along Steel Creek and another paralleling Indian Grave Branch. In addition, steel towers and new conductor would be needed where another 115-kilovolt transmission line and control cable line cross Pen Branch near Road C, where the Steel Creek lines cross the new lake south of Road B, and where the Indian Grave Branch lines cross the new lake near Road B.

The amount of time required to design and construct this alternative would be between 60 and 66 months (Du Pont, 1983d). This alternative would require about a 1-month downtime for both K- and L-Reactors. However, the shutdown of the two reactors could be scheduled at the same or different times, as desired.

Because of its structural complexity, capital costs for Kal Pond are estimated to be \$190 million, the most costly of the alternatives (Du Pont, 1983d). Annual operating costs would be approximately \$2 million. The present worth of this alternative would be \$299 million and the annualized cost would be \$35 million (Du Pont, 1983d). An estimated 870 construction personnel would be required.

The production efficiency of Kal Pond would be about 96 percent (derived from Du Pont, 1983d). Elevated Savannah River temperatures would not directly affect reactor operation. Makeup to Kal Pond would require 3.5 cubic meters per second from the Savannah River; of this total, about 0.5 cubic meter per second would be released to Pen Branch and Steel Creek.

Under extreme summer meteorological conditions, the overflow would have an exit temperature of about 33°C. Under average conditions, the discharge temperature would be about 31°C. Near-ambient temperatures should be reached at the Steel Creek and Pen Branch deltas. Thus, this alternative would have minor effects on the temperature of the Savannah River water. The water discharge rate from Kal Pond to Steel Creek and Pen Branch would be equal to their normal seasonal flow rates.

This alternative would provide normal compliance with the maximum 32.2°C discharge temperature limit.

Kal Pond is expected to show thermal behavior much like that of Par Pond. It should experience thermal stratification from April through October, and should be well mixed from November through March. During periods of thermal stratification, the hypolimnion could become intensely anoxic with ferrous iron and other metals being dissolved from the sediment (Marshall and LeRoy, 1971). The seasonal cycling of cesium-137, which follows the seasonal stratification cycle (Alberts et al., 1979), would be probable.

Because this recirculation alternative would greatly reduce the thermal discharge to Steel Creek, it would result in a significant reduction in impacts to the biota of the creek, its delta, the floodplain, and the Savannah River in comparison to the effects caused by direct discharge. A reduction of thermal impacts to Pen Branch and the Pen Branch delta would also occur.

Approximately 615 acres of riparian wetlands and 2005 acres of upland conifers would be inundated by the Kal impoundment. This would include 7.0 kilometers along Pen Branch, 5.0 kilometers along Steel Creek, and 4.0 kilometers along Indian Grave Branch. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOI, 1981). The mitigation planning goal specifies that there be "no net loss of inkind habitat value." This impoundment would flood forested habitats that once contained the endangered red-cockaded woodpecker. This lake would support minimal aquatic life because of continually high water temperatures.

Kal Pond would require a maximum of 3.5 cubic meters per second of water from the Savannah River. Assuming that K-Reactor currently uses 17 cubic meters of water per second, the current impingement is about 5840 fish per year (based on the latest 12 months of data) and the current entrainment is 7.7×10^6 eggs (1982 data) and 11.9×10^6 larvae (1983 data) per year. These values would decrease to 1858 fish per year and 2.5×10^6 eggs and 3.8×10^6 larvae per year, respectively, for the combined operation of K- and L-Reactors.

Radiocesium transport from Steel Creek is expected to be about 0.8 curie per year. Small quantities of radiocesium also would be delivered to the river and swamp from Pen Branch. Approximately 20 curies of cesium-137 that are in the Steel Creek channel and floodplain would lie beneath the lake. In addition, the Savannah River would receive about 870 curies of tritium per year from L-Reactor.

Nonradioactive atmospheric releases would result in (1) a maximum of 25 hours per year reduced visibility (less than 800 meters) on the leeward side of the impoundment, and (2) a maximum of 15 hours per year of ice accumulation on horizontal surfaces. No deposition of salts due to drift is expected.

Twenty-nine archeological sites could be affected by this alternative. Of these, 8 to 10 sites could be flooded. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Little or no change is expected in the substrate, erosion, or sedimentation patterns in Steel Creek or Pen Branch because the overflow would not produce large increases to their normal flows and because, below the reactor outfalls, the streams are in approximate equilibrium for flow rates of 11 cubic meters per second.

Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the jurisdictional wetlands upstream of the embankment, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would

have no effect on net cesium transport estimates. All uncontaminated material would be removed and used for backfill in the borrow areas.

The chemical characteristics of the overflow to either stream are expected to be similar to those of Savannah River water and the natural conditions of the receiving streams. No appreciable changes in the characteristics of the blow-down should occur as the result of river water (makeup) passing through Kal Pond, except its concentration of suspended solids would be lower. The water quality of Kal Pond should be similar to that of Par Pond; these lakes would be nearly equal in size (Kal Pond would contain 8.37×10^7 cubic meters and Par Pond contains 6.62×10^7 cubic meters). An ion-concentration (lake-to-river-water) ratio of 1.0 to 3.2 is expected for Kal Pond (Tilly, 1974). The concentration of tritium could reach 91,000 picocuries per liter, about 2.5 times the 7-year Par Pond average.

Kal Pond construction would vastly alter water levels and circulation patterns over 2620 acres, which would affect Steel Creek, Pen Branch, and Indian Grave Branch upstream of the dam. Erosion control and removal of much of the dredged material to the onsite burial ground would minimize the discharge of material that could obstruct or change the direction or velocity of flows both above the embankments and in Steel Creek and Pen Branch below the embankments.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would include those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.) plus those (i.e., 615 acres of wetlands and 2005 acres of uplands) resulting from the Kal Pond alternative. Any mitigative effects resulting from this alternative would not begin until the end of the 66-month construction period.

4.4.2.4.3 High-Level Pond

Two embankment sites across Pen Branch were studied for the construction of a High-Level Pond; both would provide the same water elevation (83 meters). The first site would have provided a lake area of approximately 1225 acres, which could not match the cooling efficiency of the other cooling lakes studied. Therefore, a second site (Figure 4-40) was studied that would add 560 acres to the first lake. The embankment for the second lake would be about 2750 meters long with a maximum height of 35 meters. Two sections of earthen berm would be constructed across a natural saddle west of this embankment; they would total 460 meters long but not more than 3 meters high. The total amount of material required to construct the embankments would be 1,900,000 cubic meters.

This lake would be upstream from the existing river water lines and, therefore, would have no impact on them or on the steam line from K-Reactor to L-Reactor. However, it would require the abandonment of Road C between Roads 6 and 7; approximately 1200 meters of Road 6 would have to be raised as much as 12 meters. About 6 kilometers of 115-kilovolt transmission line and its buried

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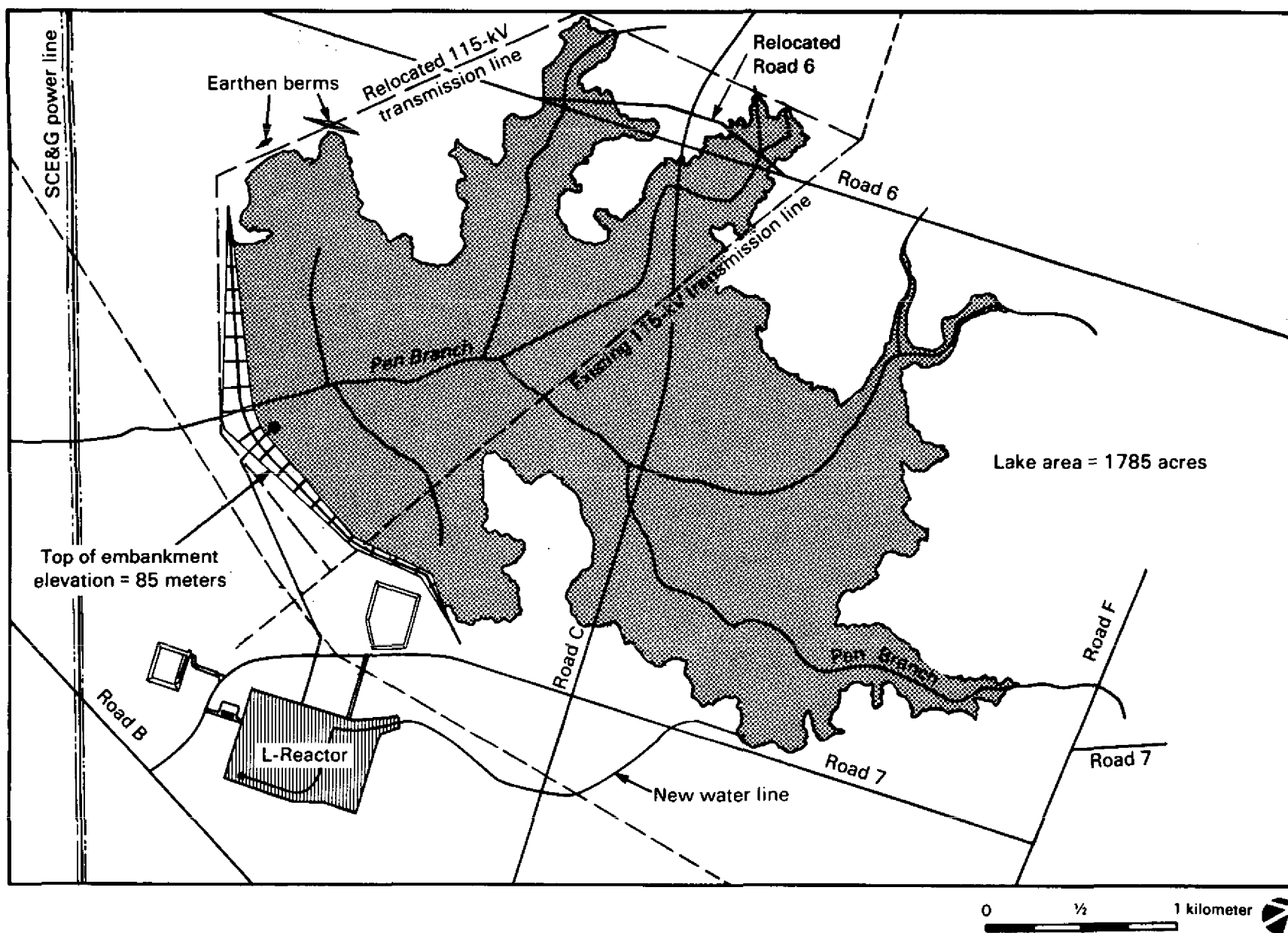


Figure 4-40. Conceptual design for High-Level Pond.

supervisor control cable would have to be relocated. Access roads for construction activities would be routed to minimize environmental impacts.

Thermal effluent from L-Reactor would flow through existing pipes to a new reinforced concrete sump, similar to that required by the cooling-tower alternative. The pumps in this sump would pump the hot water through a new pipeline to discharge into the High-Level Pond. The water would flow through the lake to an intake structure near the embankment. A new pipeline would run 1750 meters, from the intake structure, through the embankment, and to the L-Reactor lake. Valves would control the gravity flow to provide the quantity of water required for reactor cooling. Approximately 42 to 48 months would be required to design, construct, and permit this alternative.

L-Reactor shutdown time under this alternative would be the same as that for the cooling towers, because the same pumping system would be constructed. All other construction would take place away from the effluent system.

Estimated capital costs for the High-Level Pond would be about \$120 million. Annual operating costs should approach \$1.9 million. The present worth of this alternative would be \$174 million and the annualized cost would be \$20.4 million (Du Pont, 1983a). An estimated 1215 construction personnel would be required.

The High-Level Pond is estimated to have a relative production efficiency of 96 percent. This alternative would allow all of Steel Creek to remain in post-thermal recovery, unaffected by cooling-water effluents from L-Reactor. In addition, thermal discharges to the Savannah River and its associated floodplain swamp would remain at present levels. High-Level Pond makeup water would increase withdrawal from the Savannah River by 9 percent (1.8 cubic meters per second) over present withdrawal rates. Approximately 0.5 cubic meter per second would be released to Pen Branch.

Under extreme summer meteorological conditions, the overflow from High-Level Pond would have an exit temperature of about 35°C. Under average conditions, the temperature would be 34°C. This thermal discharge would impact biota in the 4-kilometer section of Pen Branch between the embankment and the stream's confluence with the K-Reactor thermal effluent (Indian Grave Branch), because the stream waters would be slightly above ambient. Ambient temperatures in Steel Creek would be unaffected by L-Reactor operation.

This alternative would not comply with the maximum 32.2°C State discharge temperature nor would it comply with the 2.8°C allowable temperature rise limit in Steel Creek.

Because this recirculation alternative would greatly reduce the thermal discharge to Steel Creek, it would result in a significant reduction of impacts to the biota of the creek, its delta, the floodplain, and the Savannah River in comparison to the effects caused by direct discharge.

The High-Level Pond would be similar to Par Pond. With time, a resident community of flora and fauna would develop from those hardy organisms that either were present before the impoundment or that might be introduced during the addition of makeup water.

After the impoundment, a portion of Pen Branch would remain as stream habitat between the High-Level Pond and the thermally impacted reach below K-Reactor. The stream flow and water temperatures in this portion would be affected little by the operations of K- and L-Reactors. However, surviving fish in this segment would become essentially landlocked; their access to upstream portions would be prevented by the High-Level Pond dam and their access to downstream portions and the floodplain swamp would be limited to periods of K-Reactor shutdown.

The High-Level Pond would inundate approximately 1175 acres of upland forest habitat, and about 610 acres of riparian wetlands associated with three headwater tributaries of Pen Branch. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOI, 1981). The mitigation planning goal specifies that there be "no net loss of in-kind habitat value." Some acreage would be used for pipeline rights-of-way. This impoundment would not affect documented habitats of endangered or threatened species.

High-Level Pond makeup water would increase withdrawal from the Savannah River by 9 percent (1.8 cubic meters per second) over present usage. This increase would raise current impingement losses by about 956 fish per year and entrainment losses by 1.3×10^6 eggs and 1.9×10^6 larvae per year.

Radiocesium transported from Steel Creek is expected to remain at its current level of about 0.25 curie per year. Small quantities of cesium-137 would be transported from Pen Branch. In addition, the Savannah River would receive about 5820 curies of tritium per year from L-Reactor.

Nonradiological atmospheric releases would result in a maximum of 10 hours per year of reduced visibility (less than 800 meters) on the leeward side of the impoundment. No icing or salt deposition due to drift is expected.

This upland area characteristically has fewer archeological sites than floodplain areas. Eight to 10 sites, of which one or two would be eligible for the National Register are estimated to exist in this area; they would be subject to flooding. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

The chemical characteristics of the overflow are expected to be similar to those of the waters of Pen Branch and the Savannah River, except the concentration of suspended solids would be lower. The water quality of the High-Level Pond should be similar to that of Par Pond. An ion-concentration (lake-to-river) ratio of 1.0 to 1.3 is expected for the High-Level Pond (Tilly, 1974).

The overflow to Pen Branch would not cause any erosion or sedimentation patterns to change in the stream or its delta because its flow would be increased significantly from its present level. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the jurisdictional wetlands upstream of the embankment, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All uncontaminated material would be removed and used for

backfill in the borrow areas. Thus, any impacts on water quality and turbidity would be temporary until suspended particulates settle and bottom sediments stabilize.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would include those described in Section 4.4.2.2.1 for once-through direct discharge (i.e., loss of 730 to 1000 acres of wetlands, etc.) plus those (i.e., loss of 610 acres of wetlands and 1175 acres of uplands) resulting from the High-Level Pond alternative. Any mitigative effects resulting from this alternative would not begin until the end of the 48-month construction period.

4.4.2.4.4 Par Pond

Under this alternative, the existing Par Pond would be used to cool the effluent from both P- and L-Reactors. A pumping station similar to that required for the cooling-tower alternative, but with larger pumps (because of the longer distance) would be built south of L-Reactor (Figure 4-41). An underground discharge pipe from these pumps would run to the northeast to a knoll on the ridgeline between the watersheds of Pen Branch and Lower Three Runs Creek (Par Pond). At this point, the pipe would discharge into a new excavated canal similar to those constructed to carry P- and R-Reactor effluents to Par Pond. The new canal would follow the ground contours to the northeast to connect to Pond A near the R-Reactor effluent canal. From this point, the cooling water for L-Reactor would follow the same path through Par Pond that R-Reactor cooling water followed when that reactor was operating.

The Par Pond pumphouse served both P- and R-Reactors for some time but would require modification to serve both L- and P-Reactors; at present this pumphouse has a capacity for only one and a half reactors. Some new underground pipelines would be required to return Par Pond water to the L-Reactor reservoir. The amount of time required to design and construct this option should range between 30 and 44 months (Du Pont, 1982b). This alternative would use the same pumping system as the cooling-tower and High-Level-Pond alternatives. Therefore, the same 1-month shutdown would be required.

The estimated capital costs for the Par Pond alternative would be \$104 million. Annual operating costs would be approximately \$4.3 million. The present worth would be \$178 million and the annualized cost would be \$20.9 million (Du Pont, 1983d). An estimated 360 construction personnel would be required.

The relative production efficiency of Par Pond should be about 96 percent (derived from Du Pont, 1982b) of that for the direct discharge option. Water withdrawn from the Savannah River would increase by about 17 percent (3.5 cubic meters per second) over present usage by SRP, including the use of Par Pond for cooling P-Reactor.

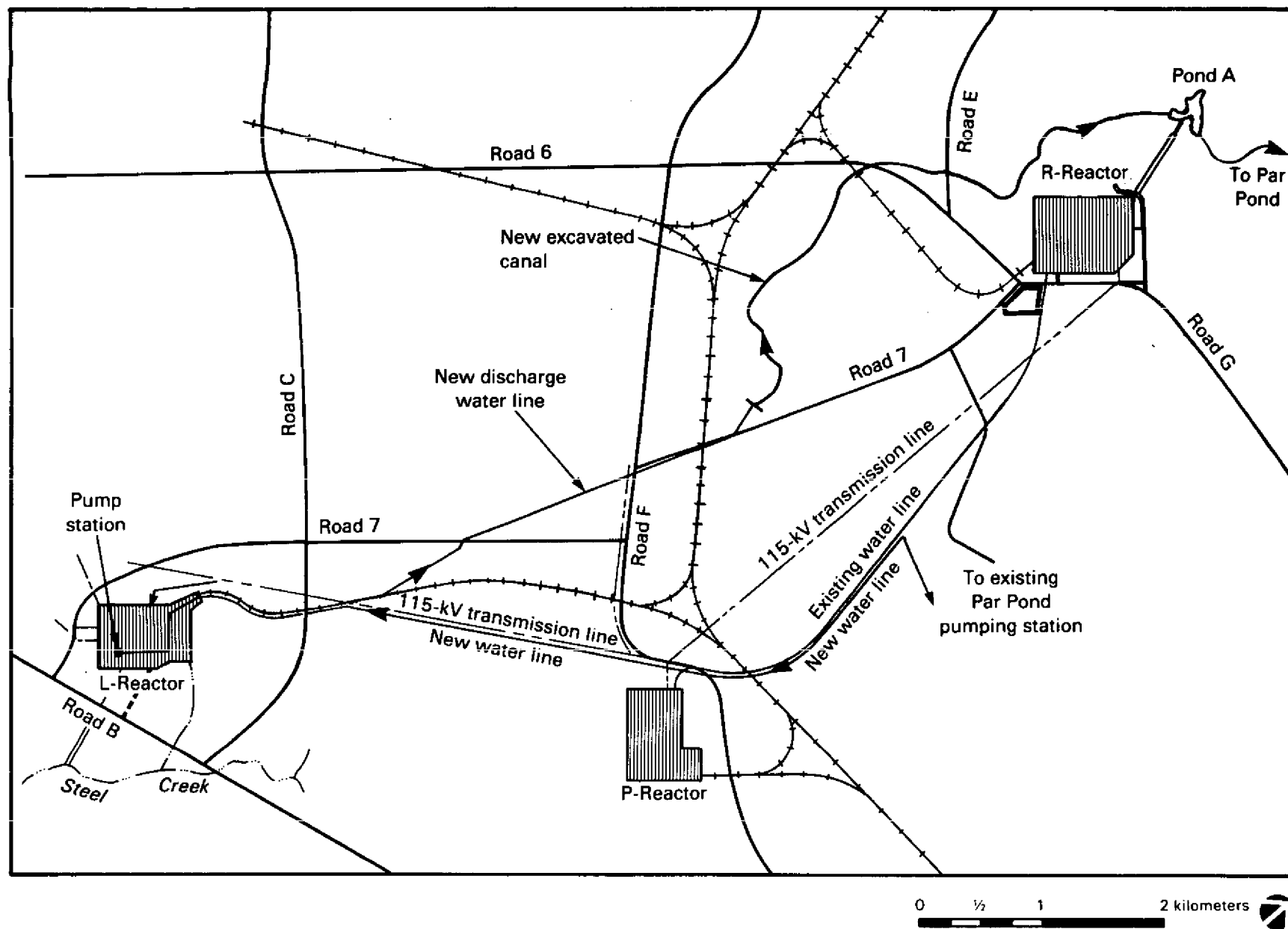


Figure 4-41. Conceptual design for the Par Pond cooling-system alternative.

Under extreme summer meteorological conditions (Section 3.1.1), the overflow would have an exit temperature of about 33°C, which is about 4° to 5°C higher than the maximum summer temperatures measured in Lower Three Runs Creek below Par Pond. During average summer conditions, the discharge would be at 31°C. Thus, only minor thermal impacts would occur to Lower Three Runs Creek or the Savannah River as the result of both L- and P-Reactors discharging thermal effluents to Par Pond. The thermal stratification and chemical cycling in Par Pond are described in Marshall and LeRoy (1971) and Alberts et al. (1979).

This alternative would not produce thermal impacts on Steel Creek. It would provide normal compliance with the maximum 32.2°C State discharge temperature limit.

Because this recirculation alternative would greatly reduce the thermal discharge to Steel Creek, it would result in a significant reduction in impacts to the biota of the creek, its delta, the floodplain, and the Savannah River in comparison to the effects caused by direct discharge.

Because Par Pond already exists, any modifications of terrestrial habitat would be limited to a temporary disturbance to approximately 50 acres to construct a new pipe discharge canal and pipelines. This 2700-acre lake, however, contains a diversified and abundant assemblage of aquatic and semiaquatic biota, including more than 100 American alligators (Murphy, 1981). This alternative would increase water temperatures in the north arm (former R-Reactor discharge arm) of Par Pond, and potentially displace the alligator and wintering waterfowl.

Increasing water temperatures in Par Pond in the summer could affect reactor operating power. The water withdrawal rate for both P- and L-Reactors (about 3.5 cubic meters per second) would cause the impingement losses of 1858 fish per year and entrainment losses of 2.5×10^6 fish eggs and 3.8×10^6 fish larvae per year.

Radiocesium transported from Steel Creek is expected to remain at its current level of about 0.25 curie per year. A small amount of radiocesium is transported from Lower Three Runs Creek to the river (Shure and Gottschalk, 1976; Gladden, 1979); this alternative could increase the rate of transport but only by a minor amount (i.e., 0.25 curie). In addition, L-Reactor would discharge about 3600 curies of tritium to Par Pond each year (Du Pont, 1982b); in addition, several curies of radiocesium would be remobilized from the R-Reactor cooling-water canal and lakes enroute to Par Pond. The total release of tritium to the Savannah River from L-Reactor would be 6270 curies per year.

Nonradiological atmospheric releases would result in (1) a maximum of 20 hours per year of reduced visibility (less than 800 meters) on the leeward side of the impoundment, and (2) a maximum of 15 hours per year of ice accumulation on horizontal surfaces. No deposition of salts due to drift is expected.

Four archeological sites are known to exist and an estimated four others would occur in the impact area. One of these sites would be subject to impacts caused by the reworking of the ground. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Little or no change is expected in erosion or sedimentation patterns in Lower Three Runs Creek because the overflow discharged to the creek would remain approximately the same as it is now and the creek bed is in equilibrium with this flow rate. There would be no change in the chemical characteristics of the overflow from Par Pond dam. Dredged material would be monitored and handled to meet applicable regulatory requirements. Thus, no adverse impacts to water quality, aquatic substrate, or existing turbidity levels would occur.

This alternative would require the following permits or processes: (1) an NPDES permit, (2) a 316(a) demonstration, (3) consultations with the FWS, and (4) the preparation of a biological assessment for endangered species. A U.S. Army COE 404 permit would not be required.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetlands). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 for once-through direct discharge (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the construction period.

4.4.2.5 Other alternatives

The alternatives described below are not intended to be used alone, but rather in combination with either direct discharge (reference case) or one of the cooling-water mitigation measures.

4.4.2.5.1 Thermal cogeneration

Different thermal cogeneration systems were evaluated (ADL, 1983) for technical and economic feasibility at the Savannah River Plant. This study considered the following alternatives:

- Heat pumps for onsite steam generation
- Electrical production with Rankine cycles
- Onsite industrial applications in which private industry would construct new plants on SRP that would use the energy in the effluent streams
- Onsite agricultural/aquacultural applications
- Hot water delivery to offsite users

The study considers only the first two alternatives to be economically attractive. However, the thermal mitigation achieved by these alternatives is insignificant. If either of these alternatives is considered for installation, it would have to be justified on its own energy recovery.

Two different scenarios were considered for onsite steam generation. The first one would use an open-open cycle heat pump system to produce 1.9 kilograms per second of 275,790-pascal steam for use in L-Area. The preliminary cost

estimate indicated this option was economical. However, the option would remove only 0.3 percent of the heat from the effluent stream. This reduction amounts to an insignificant 0.3°C drop in effluent temperature at the outfall. Using the results, a preliminary assessment of using heat pumps to generate steam was completed (Du Pont, 1983g). The assessment made the following conclusions:

- The system would be unreliable for continuous operation because the reactor would not operate continuously.
- The steam from the river water would contaminate the system it served.

In summary, the heat pumps would have a minor thermal mitigation effect and appear to be unfeasible for SRP operation.

A Rankine cycle using ammonia as the working fluid has been proposed to generate electricity from the energy in the heated effluent. ADL (1983) discussed variations on the basic system.

The Rankine cycle would lower the effluent temperature from 71°C to 49°C. The effluent flow was assumed to be 11 cubic meters per second. For the Rankine cycle alone, 58 cubic meters per second of cooling water would have a temperature drop from 23°C to 19°C across its cooling tower. This tower design is a 14°C wet bulb, 9°C approach tower. The preliminary power output was revised in a followup study (Du Pont, 1983g) to be 29 megawatts.

Capital costs (ADL, 1983) for the Rankine cycle are \$101 million. The Du Pont (1983g) estimate is \$270 million. Approximately 8 to 12 years would be required for research and development, design, and construction of the Rankine cycle. Currently, the largest commercially available and proven units are in the 1-megawatt range and operate at source temperatures greater than 93°C (Du Pont, 1983g).

The Rankine cycle could also be used in a precooler mode (ADL, 1983), which would slightly improve the economics. In the precooler mode, the effluent leaving the Rankine cycle evaporator would be piped to a cooling tower. This tower would be separate from the Rankine cycle tower. Because of the low reliability of the Rankine cycle, the effluent cooling tower would be sized to handle the inlet water temperature directly from the reactor heat exchangers. By lowering the inlet temperature of the tower to 49°C, which is possible by the Rankine cycle, the coolant exit temperature from the tower would be approximately 0.6°C lower than when the inlet water temperature is 71°C. This lower exit temperature is based on using the 27°C wet bulb and 2.8°C approach cooling towers. If the cooling-water system was operating in a complete recirculation mode, the reactor power would be increased slightly. The increased reactor power would be worth \$540,000 (Du Pont, 1983e) on a yearly basis if the complete recirculation mode was in use continuously.

The environmental effects of the Rankine cycle would differ depending on whether it was used alone or in a precooler mode. For the precooler mode, the environmental effects would be nearly identical to those described for the partial recirculation cooling-tower alternative, because similar amounts of water are being evaporated in both cases.

If the Rankine cycle is used in its standalone operation, a combination of environmental effects would occur for cooling towers and the direct discharge alternative. Because the Rankine cycle has its own cooling tower, the environmental effects of fogging, icing, etc., for cooling towers would be applicable. The reactor effluent would leave the Rankine cycle evaporator at 49°C and enter the L-Area outfall. This temperature is the equivalent of running L-Reactor near 1200 megawatts. The entire Steel Creek system at this reactor power would still be above 32.2°C. Because of the cooler water temperatures than those produced by the direct discharge case, larger backwater areas could exist with temperatures low enough to support aquatic biota. Other than this exception, the environmental impacts on Steel Creek for the Rankine cycle would be similar to those for the direct discharge case.

The ADL (1983) report also considered some Rankine cycle cases that would have altered the existing reactor heat exchangers. As with the heat pump cases, these variations are not economically feasible and could compromise reactor safety.

4.4.2.5.2 Low-head hydropower

Planning studies were carried out (Tudor Engineering Co., 1980) to evaluate the potential for hydroelectric power generation along the existing effluent channels that convey the cooling-water discharges from K- and C-Areas. The cooling-water discharge from each area is about the same as that for L-Reactor, and the effluent channels for each area convey the cooling-water discharges from an existing outlet pipe to a natural stream similar to L-Reactor. Therefore, the K- and C-Area studies as well as other studies (Jarriel and Price, 1979; Price, 1980) provided a basis for the following paragraphs.

Two locations for turbines were considered. Both are shown in Figure 4-42. The upstream location would include a penstock attached to the existing pipe that would carry the cooling effluent from the effluent sump to the outfall. This new penstock would bypass the outfall and discharge the effluent to Steel Creek downstream of the outfall. Energy would be generated by passing the water through a single hydroelectric turbine of the propeller type shown in Figure 4-43. The other location for a turbine would be below a new embankment impounding a 500-acre lake. The lake would provide cooling for reactor effluent before its discharge into the swamp and the Savannah River.

A turbine located beside the L-Reactor outfall would have a capacity of about 1100 kilowatts and generate about 7700 megawatt-hours annually. This power plant would cost about \$11.5 million to construct. Annual operation and maintenance would cost about \$100,000. The value of the energy produced was assumed to be \$0.17 per kilowatt-hour. The project could be completed in mid-1985.

An alternative system for an outfall turbine would attach the turbine to a spray cooling pipe. The spray cooling valves would be closed during the late fall and winter, when they would not be necessary. With the spray cooling turned off, turbine generation would occur as it would in the conventional system beside the outfall. Some generation could be possible when the spray cooling system was operating. The savings in energy from hydroelectric generation for this alternative does not justify the additional cost.

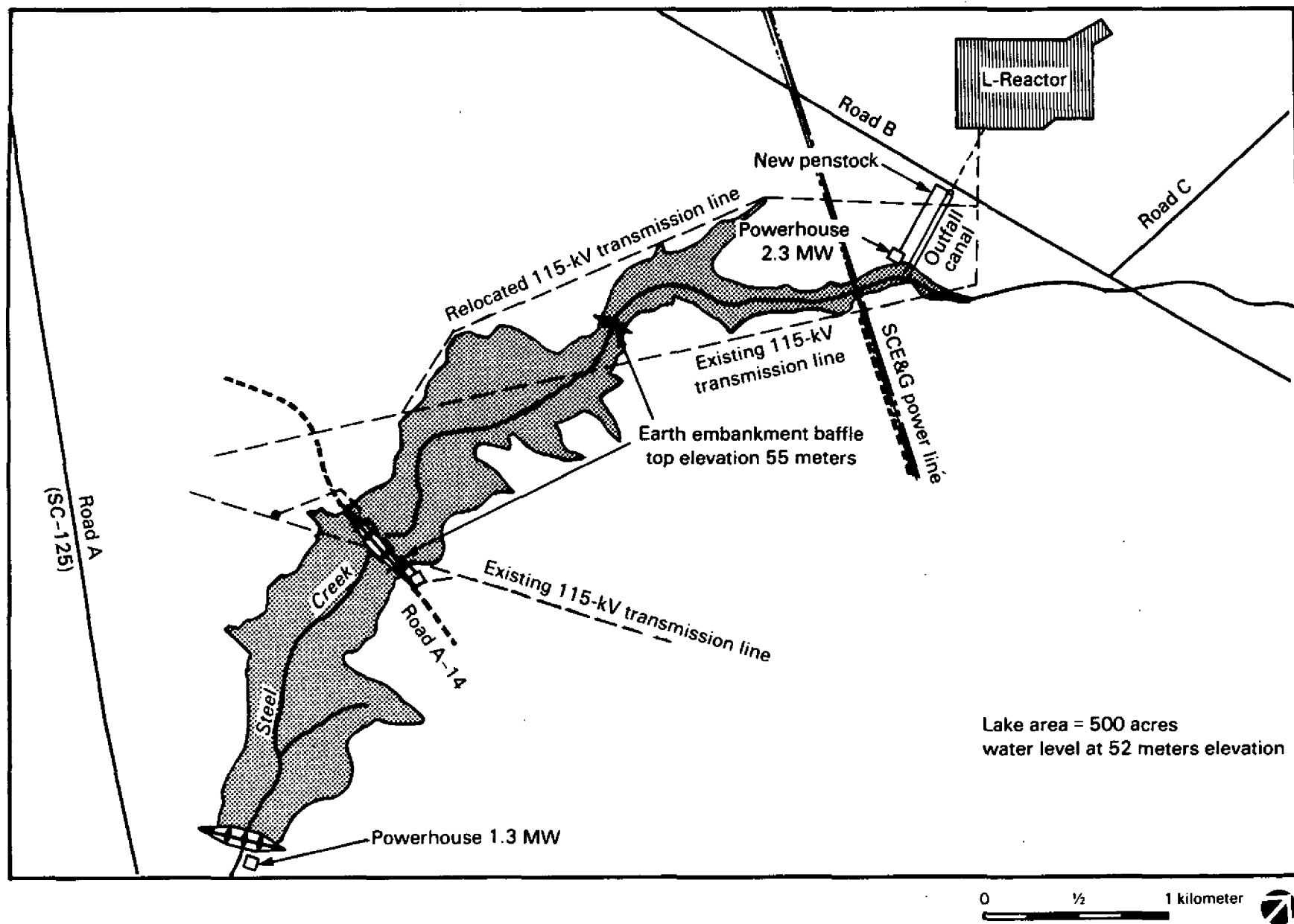
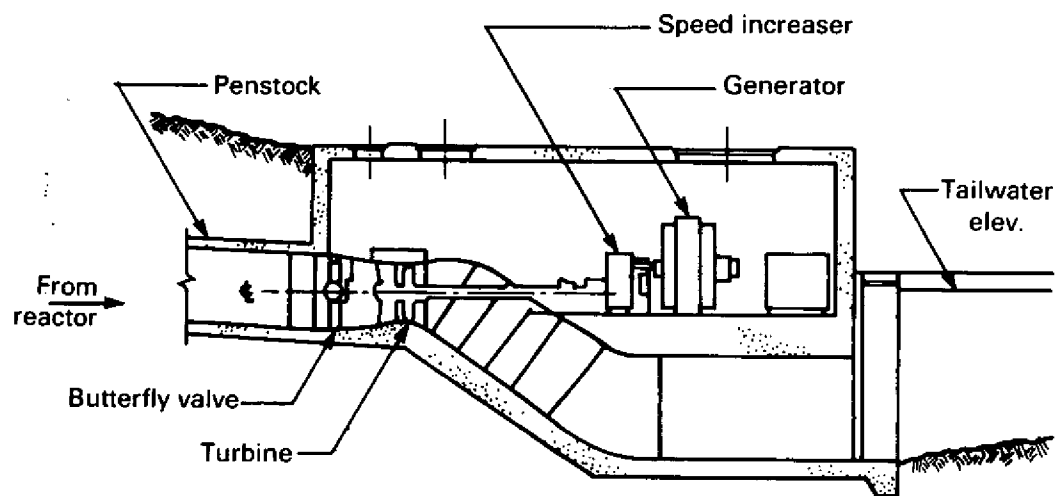
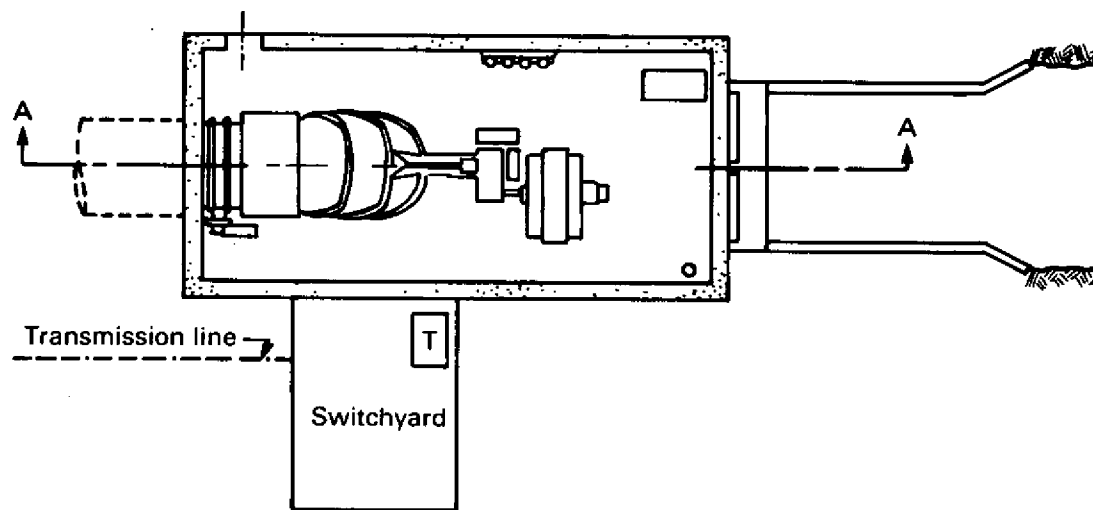


Figure 4-42. Location of outfall and below-embankment powerplants.



Section A-A



Plan
Power plant
scale 1" = 10'

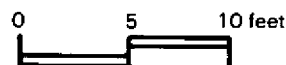


Figure 4-43. Powerhouse and turbine for outfall and below-embankment powerplants.

If a 500-acre lake was built to allow once-through cooling for L-Reactor, it might be economically feasible to install a hydroelectric turbine in the outflow. The turbine would attach to the normal release from the lake and discharge into Steel Creek. There would be no temperature reduction due to the addition of hydroelectric power, but the economics of the 500-acre lake would benefit from energy savings.

A power plant below the embankment would have a capacity of about 1350 kilowatts and generate about 9440 megawatt-hours annually. The additional cost for the hydroelectric plant would be about \$4.9 million. Construction would be complete only a few months after that of the embankment. The annual operation and maintenance cost would be about \$100,000 per year.

Another alternative considered was construction of both the outfall plant and the plant below the 500-acre lake. For the combined system, the economic benefits of the plant below the 500-acre lake would be the same as those described above. The economics of the outfall power plant would be reduced due to the head reduction resulting from a higher tailwater (the 500-acre lake). For the combined system the outfall power plant would still cost about \$11.5 million and could be complete in mid-1985. However, the capacity would be reduced to about 1000 kilowatts and annual generation would be about 7000 megawatt-hours.

The use of hydroelectric turbines along the discharge canal of L-Reactor would not reduce the thermal impact on Steel Creek or downstream wetlands. However, the hydroelectric turbines would utilize an energy source and could have a positive impact environmentally in reducing the use of fossil fuels at SRP.

4.4.2.5.3 Modified reactor operation

The total heat load discharged into Steel Creek is a direct function of reactor power. Therefore, power could, in theory, be limited to a level below that achieved at normal operating limits to control this heat load. As power is reduced, the temperature (under extreme summer conditions) would be reduced from about 80°C at the outfall for 2400 megawatts-thermal to 71°C at 2000 megawatts-thermal, to 53°C at 1200 megawatts-thermal, and to 40°C at 600 megawatts-thermal. The temperatures within the Steel Creek system would also be affected by reactor power levels. Simultaneous reduction of power and flow would increase the outfall temperatures higher than those reported above and, therefore, offer little benefit to the upper portions of Steel Creek.

While low power operation would not be practical for extended periods of time, it could provide a means of meeting thermal limitations for short periods. If the power were reduced, cooling-water flow could also be set to reduce either the total flow or the temperature of Steel Creek. At reduced power, production efficiency would be correspondingly reduced.

When modified reactor operation is used in conjunction with alternative cooling systems, the temperature of the effluent could be reduced further. For example, temperatures in the lower portion of the Steel Creek and in the swamp and Savannah River downstream of Steel Creek would be determined not only by the operating power and cooling-water flow of L- and K-Reactors, but also by the atmospheric conditions and river temperatures and flow. Thus, this option could be appropriate during periods of extreme meteorological conditions (such as occurred between July 11 and 15, 1980).

If extreme conditions combined to provide a thermal plume in the river that is large enough to threaten the zone of passage, then the power and cooling-water flow to either or both reactors could be adjusted.

4.4.2.5.4 Fisheries management programs

As discussed in Section 4.1.1, the reference case (direct discharge to Steel Creek) would have adverse thermal, entrainment, and impingement effects on some of the biological systems in Steel Creek and, to a lesser extent, the Savannah River. One option for mitigation of these effects would be the provision of replacement habitat or substitute individuals to compensate for the losses incurred. Although such losses would not be confined to one trophic level or group of aquatic organisms, the mitigation alternatives would focus on fish because of their commercial, recreational, or ecological value, and, in one case, their endangered species status.

This alternative would use the existing cooling-water system without any modifications and would have no effect on any impact of L-Reactor operation other than fish losses.

Based on recent Savannah River and Steel Creek surveys (ECS, 1983a,b; Smith et al., 1982), the fish species most likely to be affected by the various environmental effects associated with once-through cooling from the Savannah River and direct discharge to Steel Creek would be American shad, striped and largemouth bass, blueback herring, catfish and sunfish (Table 4-53).

Table 4-53. Fish species impacted by direct discharge to Steel Creek

Environmental effect	Potential fish species affected
Entrainment of fish eggs and larvae	Blueback herring, striped bass, American shad
Impingement of fish	Clupeids (shad and herring), centrachids (sunfish)
Loss of spawning/nursery habitat in Steel Creek/swamp system	Channel catfish, redear and bluegill sunfish, largemouth bass, blueback herring
Effect of Steel Creek thermal plume in the Savannah River	Blueback herring, striped bass, American shad

Other species that were considered for possible mitigation action include the Atlantic sturgeon because of its commercial value and the shortnose sturgeon because of its endangered species status.

Replacement mitigation alternatives would include the following:

- Restock impacted species either by an onsite fish hatchery or through a cooperative agreement with local state and/or Federal fish hatcheries.

- Protect wetlands similar to the Steel Creek/swamp system by purchasing or establishing a fisheries/wildlife preserve.
- Conduct or support research as part of a coordinated Savannah River fisheries management program and/or support the development of culturing techniques for fish species that are not currently being raised for restocking purposes.

4.4.2.5.5 Restocking

The criteria used to select fish species for mitigation alternatives include present and potential commercial and recreational value, ecological value, endangered species status, and existing culture capacity and/or culture feasibility. Table 4-54 identifies both the species and the criteria for their selection.

The ecological value criterion was based on present or potential importance to the Savannah River ecosystem without consideration of system-carrying capacity. The culture feasibility criterion included availability of broodstock, availability of hatching and rearing techniques and present production capacity of local hatcheries. Cost was not considered as a criterion for species selection; however, cost estimates are provided below after a description of the mitigation alternatives.

The Savannah River Plant has several sites that are suitable for fish hatching and rearing, including the Flowing Streams Laboratory on Upper Three Runs Creek and the Par Pond facilities. Both a hatchery facility and rearing ponds would be required. Well water at a flow rate of 760 to 1135 liters per minute would be required for the hatching operation; surface water would be suitable for the rearing ponds. Costs to modify an existing facility for the hatching operation would be approximately \$250,000; the construction of a new facility would cost approximately \$400,000. Construction of the 10 to 12 0.5-acre rearing ponds would cost as much \$400,000. Annual cost to operate the facilities, including support for a fish hatchery biologist and two technicians, would be at least \$250,000. Approximately 18 months would be required to design and construct the facilities. Depending on the fish species cultured, full-scale production could be achieved in 5 to 10 years. A wastewater-treatment lagoon could be required for rearing-pond effluent but would probably not be required for the hatching facility.

Based on the species selection criteria, American shad and/or blueback herring are the best candidates for an SRP hatchery operation. No local hatcheries currently exist for these species. Broodstock could be obtained by gill netting in either the Savannah River or Upper Three Runs Creek. Techniques for fertilizing the eggs and hatching the embryos are available. However, problems have previously been encountered in rearing shad and herring fry to stocking size because of their susceptibility to handling stress at this life stage. Stocking at the larval stage could be required to minimize handling mortality. Several local striped bass hatcheries are already in full production. Also, collection of striped bass broodstock would be difficult. However, striped bass fingerlings could be obtained from another source and reared in SRP ponds. Techniques for hatching and rearing Atlantic and shortnose sturgeon are not available, but are currently being developed at the Orangeburg National Fish

Table 4-54. Criteria for selecting fish species for mitigation alternatives

Candidate species	Commercial value		Recreational value		Ecological value	Endangered species	Culture feasibility
	Existing	Potential	Existing	Potential			
ANADROMOUS SPECIES							
Striped bass	None	Low	Low	High	Unknown	No	Local hatcheries in production; value of SRP hatchery would be minimal but rearing ponds are feasible.
Blueback herring	None	Medium	Low	Medium	High	No	No local hatcheries exist; SRP hatchery is feasible.
American shad	Medium	High	Low	High	High	No	No local hatchery exists; SRP hatchery is feasible.
Atlantic sturgeon	Low	Medium	Low	Medium	Unknown	No	Local hatchery is developing techniques; SRP hatchery not feasible nor practical.
Shortnose sturgeon	None	Medium	None	Low	Unknown	Yes	Local hatchery is developing techniques; SRP hatchery is not feasible nor practical.
RESIDENT SPECIES							
Channel catfish	Low	Low	High	High	High	No	Local hatcheries in production; stock could be purchased.

Table 4-54. Criteria for selecting fish species for mitigation alternatives (continued)

Candidate species	Commercial value		Recreational value		Ecological value	Endangered species	Culture feasibility
	Existing	Potential	Existing	Potential			
Largemouth bass	None	None	High	High	High	No	Local hatcheries in production; stock could be purchased.
Sunfish (redeer and bluegill)	None	None	High	High	High	No	Local hatcheries in production; stock could be purchased.

Hatchery. Obtaining and handling broodstock for these species would be a problem because of their low relative abundance and large size.

An alternative to using SRP land for hatcheries would be to obtain fish from local hatcheries. Both Georgia and South Carolina have hatchery facilities for striped bass, channel catfish, largemouth bass, and sunfish. A cooperative agreement could be established whereby SRP would provide support for the hatchery operation in exchange for fish of stocking size. The species and the number of individuals/species stocked would depend on estimates of L-Reactor impacts, mortality rate of natural and stocked fish, carrying capacity of the system stocked, and availability of hatchery fish. Cost of this mitigation alternative would be considerably less than the annual operating budget for an onsite hatchery (i.e., \$100,000 per year).

4.4.2.5.6 Protect similar wetlands

If available, a property comparable in size and wetlands value to the impacted Steel Creek/swamp area could be purchased and set aside as a fisheries/wildlife preserve. Also, property of similar size could be set aside on the SRP site. Thermal discharges from L-Reactor could reduce the spawning/rearing habitat currently utilized by fish species in the Steel Creek/swamp system. Other creeks and associated wetlands with similar spawning/rearing habitat exist between the New Savannah Bluff Lock and Dam and the lower tidal reaches of the Savannah River. A large parcel of land (greater than 1000 acres) would cost approximately \$500 per acre.

4.4.2.5.7 Support fisheries research

It could be desirable to conduct/support fisheries research. Thorough knowledge of the population dynamics and life history patterns of fish would be needed before good fisheries management decisions can be made. Recommendations for a fisheries management program based on a questionnaire completed by state and Federal fisheries biologists in the southeastern United States (Rulifson et al., 1982) emphasized these research needs. Additional research would also be required to develop techniques for hatching and rearing several species of importance to the Savannah River system, which include the shortnose and Atlantic sturgeon. A research program to collect fisheries data on selected anadromous fish species in the Savannah River would cost \$150,000 per year. An additional \$50,000 per year could be used to support the development of sturgeon culture techniques.

Initial costs (capital investment and construction), yearly operational costs, and total costs after 5 years are summarized in Table 4-55 for each of the programs described above.

4.4.2.6 Comparison of alternatives

Thirty-three alternative cooling-water systems were evaluated. The alternatives considered can be grouped into five major categories--once-through cooling lake, recirculating cooling lake, once-through cooling tower, recirculating cooling tower, and direct discharge. This section summarizes the engineering and environmental evaluations for the most favorable alternatives for each

Table 4-55. Yearly operational and total costs for mitigation alternatives

Mitigation alternative	Initial cost	Operation cost per year	5-year cost ^a
Restocking program			
SRP hatchery	\$650,000	\$250,000	\$1,900,000
Agreement with local hatcheries	--	100,000	500,000
Fisheries/wildlife preserve	500,000	10,000	550,000
Support/conduct fisheries research	--	200,000	1,000,000

^aNot adjusted for inflation.

category of cooling-water systems. This approach enables the reader to evaluate comparatively a range of reasonable alternatives, thus defining the issues and providing a clear basis for choice among alternatives. The criteria used in selecting the most favorable alternatives in each category are ability to meet South Carolina water-quality standards, production considerations, schedule, environmental factors, and the cost. Ability to expedite the schedule was also considered for these alternatives and the degree that reactor operation must be modified to meet State of South Carolina water-quality standards.

Seven once-through cooling-lake options were considered: small lakes, small lakes with upstream spray cooling, small lakes with upstream and downstream spray cooling, a 500-acre lake, a 500-acre lake with upstream spray cooling, a 500-acre lake with upstream and downstream cooling, and a 1000-acre lake. The 1000-acre lake evolved from the 500-acre lake in that it is the largest lake (thus providing better cooling and operational flexibility to comply with South Carolina water-quality standards) that could be constructed on Steel Creek in a single construction season (i.e., 6 months). For a lake size greater than 1000 acres, the construction schedule would be longer than a single construction season due to the need to build additional embankments and reroute major roads. The construction of the 1000-acre lake could also require more than one construction season if an unexpected delay occurred to the start of embankment construction. Thus, the 1000-acre lake is considered to be the best option for this category. Reduced reactor power levels would be required to comply with South Carolina water-quality standards (i.e., maintaining a balanced biological community in the lake). The schedule for lake construction can be greatly accelerated from the estimates given earlier because the U.S. Army Corps of Engineers (COE) has a staff readily available to design and construct the embankment to form the lake. This COE workforce is completing the construction of the Richard B. Russell Dam on the Savannah River and is now becoming available.

Four recirculating cooling-lake options are considered: a 1300-acre lake, Kal Pond, a High-Level Pond, and Par Pond. The Par Pond option is not considered further due to the significant impact on reactor operation for both P- and L-Reactors and the potential environmental effects on the Par Pond ecosystem. The 1300-acre lake option is considered to be the best because it requires the shortest time to implement with the least environmental effects.

Lake construction, however, would require more than one construction season. Reduced power operation would be required to maintain a balanced biological community in the lake.

For once-through cooling towers, three different designs--2.8°C, 5.6°C, and 8.4°C approach temperatures--for four different discharge options--discharge to Steel Creek, canal to swamp, spray canal and canal to swamp, and canal to swamp and pipe to the Savannah River--were considered. The 2.8°C approach cooling tower is considered the best because it has the lowest discharge temperature; direct discharge to Steel Creek is used in this comparison because it requires a minimum amount of time and cost to implement with the least impact on reactor operation (e.g., minimum annualized cost). Exceedances of the South Carolina water-quality standards of 32.2°C at the discharge point would be expected only rarely; however, a variance would have to be requested from the South Carolina Department of Health and Environmental Control (SCDHEC) for the 2.8°C temperature difference requirement. The schedule could be expedited to complete construction in slightly more than 1 year.

For recirculating cooling towers, three different designs--2.8°C, 5.6°C and 8.4°C approach temperature--for four modes of discharges--total recirculation with blowdown to Steel Creek, total recirculation with blowdown treatment prior to discharge to Steel Creek, partial recirculation with discharge to Steel Creek, and partial recirculation with refrigeration before discharge to Steel Creek--were considered. A discharge of the blowdown to Steel Creek without treatment would require a variance from the SCDHEC requirement for a delta-T of 2.8°C. The 2.8°C approach temperature with total recirculation and treatment of blowdown is used in this comparison because it meets South Carolina water-quality standards and causes the least amount of impact on reactor operation (e.g., minimum annualized cost).

Four direct discharge options were considered--direct discharge to Steel Creek (reference case), spray canal, penstock diversion to Pen Branch, and lake-canal diversion to Pen Branch. Because the spray canal would only provide a minimum amount of thermal mitigation, and because the two diversions to Pen Branch options would impact previously unaffected areas, direct discharge has been used in this comparison. DOE does not intend to pursue the option of direct discharge; its implementation would require either a reclassification of the Steel Creek system by the State of South Carolina or a Presidential exemption from the requirements of the Clean Water Act.

Table 4-56 compares engineering and environmental factors for the five alternative cooling-water systems--once-through 1000-acre lake, recirculating 1300-acre lake, once-through 2.8°C approach temperature cooling tower, recirculating 2.8°C approach temperature cooling tower with treatment of blowdown, and direct discharge. After considering all factors, DOE has selected the once-through 1000-acre lake as its preferred cooling-water alternative because it:

1. Meets all State and Federal regulatory and environmental requirements, eliminating thermal impacts on the river, swamp, and unpounded stream, while providing a productive balanced biological community within the lake
2. Provides the earliest reactor startup and the maximum plutonium deliveries of any regulatory and environmentally acceptable cooling-water alternative

Table 4-56. Comparison of cooling-water alternatives

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Schedule for implementation	36-month construction schedule could be accelerated to complete lake in one construction season (6 months).	40-month construction schedule could be accelerated to complete lake, but would take longer (two construction seasons, i.e., about 18 months) than 1000-acre due to construction of recirculating system, road relocation, and additional embankments.	27-month construction schedule might be accelerated to complete the cooling tower in slightly more than 1 year.	27-month construction schedule; cannot be accelerated because of long-lead-time procurement of pumps.	Would not require any additional time for implementation.
Preliminary cost capital (million \$)	25	73	50-55	75	0
Operating (million \$/year)	3.4	2.9	5.5	3.2	3.4
Thermal compliance	Would meet South Carolina water-quality standards with changes in operating power levels.	Would meet South Carolina water-quality standards with changes in operating power levels.	Would meet South Carolina 32.2°C standard but variance would be required from ΔT of 2.8°C requirement.	Would meet South Carolina water-quality standards.	Would require reclassification of Steel Creek to be permissible.

Table 4-56. Comparison of cooling-water alternatives (continued)

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Modification to operation	Power reduction would be necessary between late spring and early fall to maintain balanced biological community in lake. Average annual 14% power reduction. Amenable to installation of precoolers (~ \$10M capital) that would allow an increase in power efficiency.	4% inherent operating power loss. Greater than 14% power loss to maintain a balanced biological community.	Operating power of 100%; infrequent periods (once in 4.5 years) might require some reductions.	Higher temperature of recirculating cooling water would cause a reduction in operating power levels; averages 6.5% power reduction.	Operating power of 100%.
<u>Environmental Factors</u>					
Thermal effects	Balanced biological community in the lake. Steel Creek corridor, delta, and Savannah River swamp protected from thermal effects downstream from embankment.	Same as for once-through 1000-acre lake.	Steel Creek corridor, delta, and Savannah River swamp protected from thermal effects.	No effects expected.	Steel Creek corridor, delta, and Savannah River swamp to be thermally impacted. Zone of passage to remain in the Savannah River. Also, there is a serious thermal shock effect.

Table 4-56. Comparison of cooling-water alternatives (continued)

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Discharge flow effects	11 cubic meters per second to be discharged. Flow will impact downstream wetlands and will cause increased streambank erosion and delta growth below embankment.	About 0.5 cubic meter per second to be discharged below embankment. Erosion and wetland impacts downstream of embankment very small.	11.0 cubic meters per second. Erosion and delta growth would be greater than the 1000-acre lake due to erosion over longer reach of Steel Creek.	About 0.6 cubic meter per second; erosion and wetlands impacts downstream of embankment very small.	11 cubic meters per second to be discharged. Flow will impact downstream wetlands and will cause increased streambank erosion and delta growth below embankment.
Habitat impacts	735 to 1015 acres of wetlands would be affected by inundation or flow effects. 775 acres of uplands inundated.	240 acres of wetlands and 1060 acres of uplands would be inundated.	635 to 915 acres of wetlands would be affected by inundation and flow effects.	Slight impacts to wetlands.	Direct discharge will eliminate between 730 to 1000 acres of wetlands in the Steel Creek corridor, delta, and Savannah River swamp.
Water withdrawal	About 11 cubic meters to be withdrawn from the Savannah River.	About 1.8 cubic meters per second to be withdrawn from the Savannah River.	Same as 1000-acre once-through lake.	About 1.4 cubic meters per second to be withdrawn from the Savannah River.	Same as 1000-acre once-through lake.
Entrainment/impingement	Water withdrawal will cause impingement of an additional 16 fish per day and entrainment of 3 to 6% of fish eggs and larvae passing SRP intakes.	Water withdrawal will cause impingement of less than 3 fish per day and entrainment of 0.5 to 2% of fish eggs and larvae passing SRP intakes.	Same as 1000-acre once-through lake.	Slightly less than recirculating cooling lake.	Same as 1000-acre once-through lake.

Table 4-56. Comparison of cooling-water alternatives (continued)

Evaluation factors	Once-through cooling lake (1000 acres)	Recirculating cooling lake (1300 acres)	Once-through cooling towers (2.8°C approach)	Recirculating cooling tower (2.8°C approach and treatment of blowdown)	Direct discharge
Endangered species	Habitat for American alligator and wood stork to be affected. Consultations with U.S. Fish and Wildlife Service in progress.	Habitat for American alligator affected; foraging habitat for wood stork not affected.	Same as 1000-acre once-through lake.	No impacts to endangered species.	Same as 1000-acre once-through lake.
Radiocesium remobilization	Radiocesium releases primarily related to flow. Maximum release to be no more than 4.4 curies in first year. Release within applicable standards.	Radiocesium releases would be smaller due to reduction in the amount of water discharged. Maximum release would be about 0.8 curie in the first year.	Radiocesium release would be smaller than for 1000-acre once-through lake and direct discharge. Maximum release would be 3.3 curies in the first year.	Same as 1300-acre recirculating cooling lake.	Radiocesium releases due to both hot water and flow effects. Maximum release to be about 4.4 curies in first year. Release within applicable standards.
Archeological sites	Four sites would be protected by monitoring and mitigation. One site to be flooded; recovery plan approved. Further surveys identified 10 potentially significant sites; mitigative measures to be taken as appropriate.	Same as 1000-acre once-through lake.	Five sites would be protected by monitoring and mitigation.	No archeological sites would be impacted.	Same as once-through cooling towers.

3. Has the lowest costs of any regulatory and environmentally acceptable cooling-water alternative
4. Is amenable to backfitting with precooler systems, if needed, which could improve reactor operational flexibility and the production capability.

The recirculating cooling tower alternative is considered the most favorable environmentally because it would not impact wetlands, the Steel Creek corridor, or uplands. This alternative was not identified as the preferred alternative, however, because it would require about 27 months to implement, even on an expedited basis; this would cause a large, unacceptable loss in material production. In addition, it would have a very high capital cost.

The recirculating cooling lake alternative is the next most favorable environmentally; its impacts are similar to those of the recirculating cooling tower, except it would inundate about 900 acres of uplands and 400 acres of wetlands. This alternative would have very high capital costs and a long schedule for construction in relation to that for the 1000-acre cooling lake. Even on an expedited basis (i.e., 18 months), the longer schedule would result in a large, unacceptable loss in material production.

The once-through cooling tower would have similar environmental impacts to those of the 1000-acre lake, except for the acreage inundated by the impoundment and the thermal shock effects of the discharge from the cooling tower on aquatic biota during startup or shutdown of the reactor. In addition, this alternative would have a longer construction schedule, with an attendant impact on material production, would have twice the cost of the 1000-acre lake, and would require a variance from South Carolina thermal standards.

4.4.3 Disassembly-basin water disposal

4.4.3.1 Background

The disassembly-basin water becomes contaminated when tritium and other radionuclides are carried over as process water adhering to the fuel and target assemblies and when tritium is contained as water of hydration in aluminum oxide on the assemblies. The disassembly-basin water is recirculated through sand filters and deionizers to clarify the water and remove radionuclides; tritium, however, is not removed in the process, and small residuals of other radionuclides also remain (Table 4-57). When the tritium content of the disassembly-basin water has built up to a procedural control level, the water is purged from the disassembly basin. Normally the basin is purged of as much as 1,890,000 liters of water following each reactor discharge. The purge is not continuous, but occurs at a frequency that depends on the type of reactor assemblies and the frequency of discharge operations; typically, the basin is purged twice each year.

Initially, the L-Area disassembly basin would contain very little tritium because the reactor would start up with a nontritiated charge of heavy water. The amount of tritium discharged would gradually increase as the tritium content of the reactor process water increases due to neutron activation. After about

Table 4-57. Expected average annual liquid releases of radionuclides to the L-Area seepage basin--tenth year

Radionuclide	To seepage basin (Ci/yr)	To Steel Creek from ground water ^a (Ci/yr)
H-3	^b 1.1 x 10 ⁴	6.0 x 10 ³
P-32	1.2 x 10 ⁻³	--
S-35	9.5 x 10 ⁻³	2.9 x 10 ⁻⁸
Cr-51	1.8 x 10 ⁻¹	--
Co-58, Co-60	3.7 x 10 ⁻⁴	2.1 x 10 ⁻⁴
Sr-89	7.0 x 10 ⁻⁵	--
Sr-90	2.0 x 10 ⁻⁴	--
Y-91	5.1 x 10 ⁻³	--
Zr-95	1.1 x 10 ⁻²	--
Ru-106	3.4 x 10 ⁻⁴	1.7 x 10 ⁻⁵
Sb-125	8.0 x 10 ⁻³	2.6 x 10 ⁻³
I-131	6.9 x 10 ⁻³	--
Cs-134	5.1 x 10 ⁻³	--
Cs-137	4.4 x 10 ⁻²	--
Ce-144	1.9 x 10 ⁻²	3.8 x 10 ⁻⁴
Pm-147	2.8 x 10 ⁻³	8.8 x 10 ⁻⁴
Unidentified beta-gamma	8.9 x 10 ⁻²	--
Unidentified alpha	3.2 x 10 ⁻⁴	--

^aOutcrop activities after 15 years of L-Reactor operation. Due to long transport time in ground water, Sr-90 and Pu-239 would not reach outcrop until many years after L-Reactor operations have ceased. Estimated dose effects at this time are much smaller than those due to the listed radionuclides.

^bThirty percent of this tritium is expected to evaporate.

10 years of operation, the tritium content of the process water would approach an equilibrium; that is, the amount of new tritium produced would equal the amount lost through radioactive decay, leakage, and carryover during discharge operations.

The following subsections describe alternative disposal methods for disassembly-basin purge water and compare these methods on the bases of cost and offsite doses.

4.4.3.2 Discharge to seepage basin

DOE is conducting continuing studies of the detritiation of all SRP reactor moderator, the discontinued use of seepage basins, and related cleanup and remedial actions (Section F.6). Table 4-57 lists the expected annual releases of radionuclides to the L-Area seepage basin and the releases of radionuclides to Steel Creek by ground-water transport from the seepage basin.

Approximately 30 percent of the tritium entering the seepage basin would evaporate, and the remainder would seep into the ground, entering the uppermost water-table aquifer, the Barnwell Formation. The water is then expected to move horizontally, outcropping in Steel Creek approximately 4.4 years later. The quantity of tritium reaching Steel Creek is reduced to about 50 percent of that discharged to the seepage basin by evaporation and radioactive decay.

4.4.3.3 Discharge to Steel Creek

Direct discharge to Steel Creek would lose the advantage of radioactive decay found in the seepage basin disposal method. Also, concentrations of tritium and other radionuclides in Steel Creek and the Savannah River would reach maximums during purges and drop to lower levels afterward. If discharged to Steel Creek, the purge water would be diluted with cooling water and evaporative losses to the atmosphere would be small.

4.4.3.4 Evaporation

The purge water from the disassembly basin could be evaporated using a small commercially available boiler, vent stack, and dispersion fan. All the tritium would be dispersed in the atmosphere while other radionuclides would be retained in the evaporator bottoms and removed by ion change. No radioactive materials would enter Steel Creek under this alternative.

The estimated installation cost of such a unit would be \$2-3 million and the operating cost would be \$300,000 per year at \$22 per thousand kilograms of steam.

4.4.3.5 Detritiation

As discussed in Section 4.4.5, detritiation of reactor moderator in a central facility is being considered for all four SRP reactors. The moderator detritiation plant is expected to reduce equilibrium moderator tritium levels by a factor of ten. Inasmuch as the moderator would be the source of the tritium that contaminates the disassembly-basin water, a corresponding factor of ten reduction in the basin water tritium concentrations and releases from this source is expected.

4.4.3.6 Comparison of alternatives

The contribution to offsite dose of disassembly-basin discharge to the seepage basin, of direct discharge to Steel Creek, and of evaporation were calculated for the purpose of comparing these alternatives. Calculations of total dose from L-Reactor operation with discharge to the seepage basin and with direct discharge to Steel Creek can be found in Appendix B.

The amounts of tritium entering the atmosphere and liquid pathways as a result of discharge to the seepage basin, discharge to Steel Creek, and evaporation are listed in Table 4-58. These releases are predicted to occur after the tenth year of L-Reactor operation. During the first year, about one-tenth of these amounts would be released. Some radionuclides other than tritium would be released to Steel Creek, from both seepage-basin disposal and direct discharge to Steel Creek. The values listed in Table 4-57 are only those associated with disassembly-basin purge water and do not include releases from other sources such as heat exchanger leakage, process sumps, and evaporative loss from process water leaks.

Table 4-58. Tritium releases from disassembly-basin water disposal alternatives--tenth year

Release pathway	Tritium releases (Ci)		
	With seepage basin	Direct to Steel Creek	Evaporation
Atmosphere	3,200	--	11,000
Steel Creek	6,000	11,000	--

Table 4-59 lists offsite doses from the tritium and other radionuclides. Doses to the maximum individual from seepage-basin disposal would be about half of those from a direct discharge to Steel Creek and twice those expected from the use of an evaporator. Estimated population doses from an evaporator would be slightly lower than those from either a discharge to the seepage basin or a direct discharge to Steel Creek. However, these differences would be small.

There would be little difference in cost between a discharge to the seepage basin and a direct discharge to Steel Creek; the cost of either method would be small. Considering only operating costs, the cost-benefit ratio for installing an evaporator system would be \$42,000 per person-rem avoided in the offsite population doses; this is a costly alternative. The cost-benefit ratio for detritiation of the moderator would be even greater per person-rem avoided (Section 4.4.5).

Thus, DOE has selected the discharge to seepage basin as its preferred alternative; at the same time, research and development activities for detritiation are continuing for potential general application at the Savannah River Plant.

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Table 4-59. Offsite doses from disassembly-basin
water disposal alternatives--tenth year

Exposure pathway	With seepage basin	Direct to Steel Creek	Evaporator
MAXIMUM INDIVIDUAL (CHILD) DOSE (mrem/yr)			
Atmosphere ^a	0.013	--	0.044
Liquid ^b	<u>0.074</u>	<u>0.15</u>	<u>--</u>
Total	0.087	0.15	0.044
POPULATION DOSE (person-rem/yr)			
Atmosphere ^a			
80-kilometer radius	0.5	--	1.9
Liquid ^b	<u>8.6</u>	<u>15.9</u>	<u>--</u>
Total	9.1	15.9	1.9

^aTritium only released by atmospheric pathway.

^bRadionuclides other than tritium also enter liquid exposure pathway.

4.4.4 186-Basin sludge removal

4.4.4.1 Background

L-Area is equipped with a 95-million-liter reservoir (186-Basin) to hold cooling water for the reactor. The reservoir is divided into three separate basins, which are connected by sluice gates. All the water that comes from the Savannah River, which is used to cool the reactor during periods of normal operation and shutdown, would pass through the 186-Basin. The basins would also be used as settling basins to remove suspended solids from the water, thereby preventing their accumulation in the heat exchangers.

The average suspended solids concentration of the water drawn from the Savannah River is 21 milligrams per liter. The primary source of the suspended solids in the Savannah River is from the erosion of Piedmont soils above the fall line. About 2 percent of the suspended solids that enter the 186-Basin are actually deposited in the basin, amounting to about 110 metric tons of sediment on an annual basis.

The sediment that accumulates in the 186-Basin has been found to be a habitat suitable for growth for the Asiatic clam, Corbicula. Clams, which would be swept up by the water flowing to and through the reactor heat exchangers, would attach themselves to the piping and heat exchangers and continue to thrive. Eventually, the piping and heat exchangers could become fouled, or even plugged, and their ability to transmit the heat generated by the nuclear fission

process in the reactor to the secondary cooling water would be impaired. To reduce the potential for Asiatic clam growth and development, the sediment in the 186-Basin would be removed on a periodic basis.

The following is a discussion of four alternative methods that could be employed to eliminate the sediment accumulation problem in the 186-Basin. They are compared on the basis of relative effort to implement each alternative. These alternatives are as follows:

1. Batch discharge to Steel Creek
2. Land application
3. Borrow pit application
4. Continuous sediment suspension

4.4.4.2 Batch discharge to Steel Creek

During periods of reactor shutdown and after the basins have been drained, this alternative would flush the sludge to the process sewer and eventually to an onsite stream. This procedure would take about 2 weeks.

With EPA's establishment of the National Pollutant Discharge Elimination System (NPDES) permit, a daily maximum limit of 50 milligrams per liter for total suspended solids was established for discharges to surface-water streams. During the periods in which the basins were cleaned of sediment, the suspended solids concentration in the effluent to the onsite streams exceeded this limit by 10 to 110 milligrams per liter. An exemption from the suspended solids limits has been obtained for the basin-cleaning activities at C-, K-, and P-Reactors under the January 1, 1984, NPDES permit for SRP (Section 7.4). Daily composite samples for total suspended solids are required during the cleaning period, and the results must be reported annually to SCDHEC. TC

Batch discharge would allow sediments flushed from the 186-Basin in L-Area to be discharged to Steel Creek. The resuspended sediments discharged to Steel Creek would be deposited in the creek before they reach the Savannah River swamp. These sediments could possibly be resuspended and transported when the water flow in Steel Creek increases due to storms or reactor startup.

Since 1968, when L-Reactor was placed on standby status, daily maximum suspended solids concentrations in Steel Creek and in the Savannah River have been observed to exceed EPA NPDES limits due to natural causes, and are comparable to the values anticipated with the draining and cleaning of the L-Area 186-Basin. The draining and cleaning of the L-Area 186-Basin would be carried out over a period of several days to 2 weeks on an annual basis.

4.4.4.3 Land application

The sediments that need to be removed from the L-Area 186-Basin could be applied to the land to enhance growth of a vegetative cover. The sediment is essentially topsoil from the Piedmont region above the fall line that has been eroded and washed away by storm runoff into the Savannah River.

To be able to handle it in an efficient and economical manner for land application, the sediment would have to be dried to a high solids content (sludge). This could be accomplished during a scheduled extended reactor shut-down by decanting the water from the basin, leaving the sediment. This water could be discarded in the process sewer line that discharges to Steel Creek.

The remaining sediment and water (sludge) could then be transferred to a sludge-drying basin, via (1) another process sewer line or (2) truck transport. On completion of the transfer, the 186-Basin could be returned to service, with no effect on reactor restart. The sludge would dry, or thicken, under natural conditions. On reaching a solids content suitable for handling, the sludge would be trucked to a site designated for the application.

This alternative would require the construction of a basin for sludge drying and the installation of an additional process sewer line connecting the 186-Basin to the new basin, if the process sewer line option identified above were selected.

4.4.4.4 Borrow pit application

Another alternative to batch discharge to Steel Creek would be to place the material in retired borrow pits on the SRP site. These pits were sources of earth-fill material for various construction projects on the SRP.

This alternative would also require the construction of a sludge-drying basin and the additional process sewer line connecting the 186-Basin with the sludge-drying basin. The time requirements for this alternative would be similar to those for land application, and would not have an effect on reactor restart. This alternative, though, would be limited to the number of retired borrow pits on the SRP and their capacity.

4.4.4.5 Continuous sediment suspension

A means to prevent sediment accumulation in the 186-Basin would be to keep solids in suspension in the water as it transits the basin. Agitation and turbulence of the basin water would accomplish this objective.

If implemented, the suspended solids concentration of the effluent stream discharged to Steel Creek would be essentially the same as that of the water drawn from the Savannah River. The total amount of sediment discharged to Steel Creek under this alternative would be the same amount discharged under the "batch discharge to Steel Creek" alternative described above. Continuous suspension of the sediment in the 186-Basin, however, would not prevent the accumulation of sediment in the L-Reactor heat exchangers and secondary cooling piping and might improve the habitat for the Asiatic clam.

4.4.4.6 Comparison of alternatives

None of the alternatives described above would have an impact on L-Reactor restarts following a scheduled extended shutdown. The "batch discharge to Steel Creek" and "continuous sediment suspension" alternatives would have no land use requirements, but could contribute to delta growth in the Savannah River swamp. The "borrow pit application" alternative would be limited to the number and capacity of retired borrow pits on the SRP.

The "batch discharge to Steel Creek" alternative would not require funds for construction activities, while the other three alternatives would require funds for construction, equipment procurement, maintenance, and additional operating expenses.

DOE has selected the batch discharge to Steel Creek as its preferred alternative. Batch discharge is presently allowed by the SRP NPDES permit issued by the South Carolina Department of Health and Environmental Control. This permit requires the performance of a 1-year study to determine the potential environmental effects of batch discharge.

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4.4.5 Moderator detritiation

The possibility of a detritiation plant to remove tritium from heavy-water moderators in all SRP reactors is being studied. The moderator detritiation plant (MDP) would reduce moderator tritium content by a factor of ten to 1.7 curies per liter.

Tritium is formed in the heavy-water moderator by neutron irradiation of deuterium. Tritium reaches the environment through both liquid and gaseous pathways. Table 4-60 presents data for reactor tritium releases from all SRP operations. Operation of an MDP is expected to reduce reactor releases, including the contribution from L-Reactor operation, to 13 percent of the tabulated values.

Evaluation of the MDP is underway. The concept envisions the use of a central facility processing water from all four SRP reactors. The process being considered is based on catalytic exchange between heavy-water feed and detritiated deuterium gas. Tritium is extracted into the deuterium gas stream, which is cryogenically distilled to separate the tritium from the deuterium. The purified deuterium gas stream is returned to the catalytic exchange.

Two process variations are under consideration. In the first, which has been demonstrated and operated since 1972 on a scale about 1/7 of that required for SRP, a vapor phase exchange is employed. The heavy-water feed is first converted to steam, which is then mixed with the deuterium gas in contact with the catalyst. In the second variation, which has only been demonstrated on a laboratory scale, the heavy water is maintained in the liquid phase during contact with the deuterium gas stream in the presence of the catalyst. This latter variation offers the potential for significant cost savings compared to the former.

Table 4-60. Reactor tritium releases from SRP operation

Releases	Curies for 3 reactors (annual)
LIQUID	
Direct reactor releases to river	8,800
Indirect to K-Basin and Par Pond	9,800
From heavy-water rework to river	<u>2,000</u>
Total	20,600
ATMOSPHERIC	
From reactor stacks	146,000
Evaporation from disassembly and seepage basins	6,000
Total	152,000

Current estimates are based on a start of detailed design of the MDP in 1986, start of construction in 1987, and operation in 1992. By 1992, the estimated moderator tritium level will be 9 curies per liter, increasing at a rate of 0.7 curie per liter per year. Tritium releases from L-Reactor will represent about 15 percent of all SRP reactor tritium releases.

Capital costs of the MDP (escalated to the time of expenditure) are estimated to be in the order of \$125 million. Estimated annual operating cost for the first year of operation is \$6.2 million. These estimates place the cost-benefit of the MDP in excess of \$1 million per person-rem exposure averted.

4.5 PREFERRED ALTERNATIVES*

This section presents the potential environmental effects of L-Reactor operation with the implementation of the preferred mitigation alternatives (described in Section 4.4). This alternative is discussed in more detail in Appendix L.

*Because this section is new, vertical change bars are not required.

4.5.1 Preferred mitigation alternatives

4.5.1.1 Safety-system alternative

The existing confinement system is the preferred alternative. The safety-system alternatives discussed in Section 4.4.1 would mitigate the potential consequences from hypothetical reactor accidents, which have a very low estimated probability of occurrence and associated risk. Based on benefit, cost, and technical feasibility, the reference-case confinement system has been identified as the preferred safety-system alternative.

Of the six alternatives, including the reference case, only three were found to be technically feasible. Two of these feasible systems were associated with very large costs per person-rem averted, based on a postulated 3-percent core-melt accident. Again, the existing system is the preferred safety-system alternative.

As agreed in the Memorandum of Understanding between DOE and the State of South Carolina of April 27, 1983 (Congressional Record, July 14, 1983, p.S1000), DOE will, within the limits of classification, provide the State a discussion paper describing the differences between SRP production reactors and commercial power reactors and the reasons why a containment is neither feasible nor necessary on the existing SRP production reactors.

4.5.1.2 Cooling-water alternative

The preferred cooling-water alternative of the Department of Energy is to construct a 1000-acre lake before L-Reactor resumes operation, to redesign the reactor outfall, and to operate L-Reactor in a way that assures a balanced biological community in the lake as specified in an NPDES permit to be issued by the State of South Carolina.

The lake will require at least 3 to 5 years to establish and develop a balanced biological community. Initially, L-Reactor will be operated to maintain 32.2°C or less in about 50 percent of the lake. Studies will be conducted to confirm the biological characteristics and the cooling effectiveness of the lake. Following the results of these studies, L-Reactor operations will be adjusted as necessary to assure the continued maintenance of a balanced biological community.

This alternative is discussed in Section 4.4.2.2.9; it is one of 33 alternatives analyzed in Section 4.4.2. Based on discussions with the South Carolina Department of Health and Environmental Control, DOE has determined that L-Reactor operation can be modified so the 1000-acre lake would comply with South Carolina water-quality standards. Also, the Corps of Engineers has agreed to construct the embankment to form the 1000-acre lake on a much faster schedule. Because DOE has to restart L-Reactor operation as soon as practicable to produce the needed defense nuclear materials and because the schedule for constructing such environmentally preferable alternatives as a closed-cycle cooling tower cannot be greatly improved (design, construction, and long-lead-time procurement of special pumps), DOE decided to identify the 1000-acre lake as its preferred cooling-water mitigation alternative.

In addition to complying with the NPDES permit, DOE:

- Will comply with provisions of Section 404 of the Clean Water Act with regard to the construction of the cooling lake, including the required SCDHEC 401 certification.
- Will prepare a predictive 316(a) demonstration.
- Will complete a consultation process with the U.S. Fish and Wildlife Service (FWS) on the impacts of the preferred alternative.
- Will, in accordance with FWS personnel, use the Habitat Evaluation Procedures (46 FR 7644) to determine further mitigation needs. Based on this program, DOE will implement additional mitigation measures (depending on Congressional authorization and appropriations).
- Will perform an archeological survey, assessment, and data recovery, if required, of the affected area not previously studied, as required by the National Historic Preservation Act.
- Will perform safety analyses of the design of the cooling lake.

4.5.1.2.1 Description

The 1000-acre lake would be about 1200 meters wide at its widest point, would average approximately 600 meters wide, and would extend about 7000 meters along the Steel Creek valley from the embankment to just beyond Road B (Figure 4-44). The normal pool elevation of the lake would be 58 meters above mean sea level (MSL); the present elevation of Steel Creek at the dam site is 35 meters. The storage volume at the normal pool elevation would be about 31 million cubic meters.

The embankment for the 1000-acre lake would be at the same location as that for either the 500- or the 1300-acre lake. Figure 4-45 shows the relationships between these lake designs. The embankment would be approximately 800 meters upstream from the Seaboard Coast Line Railroad Bridge across Steel Creek or 1700 meters upstream from Road A. It would be 1200 meters long at the crest (Figure 4-46). The main embankment would be a maximum of about 26 meters high, 12 meters wide at the top, and 200 meters wide at the base. The elevation at the top of the embankment would be 61 meters above mean sea level to allow 3 meters freeboard for flood pool, wave action, and earthquake settlement.

An outlet structure with gates would control the discharge from the lake to a conduit running 220 meters under the embankment. This conduit would discharge into a stilling basin to reduce the velocity before the water is released into Steel Creek (Figure 4-47).

4.5.1.2.2 Lake temperatures

L-Reactor would be operated at the highest allowed power level consistent with the maintenance of the balanced biological community in the lake, as specified in the NPDES permit that is expected to be issued by the State of South Carolina. Initially, L-Reactor would be operated to maintain 32.2°C or less in about 50 percent of the lake.

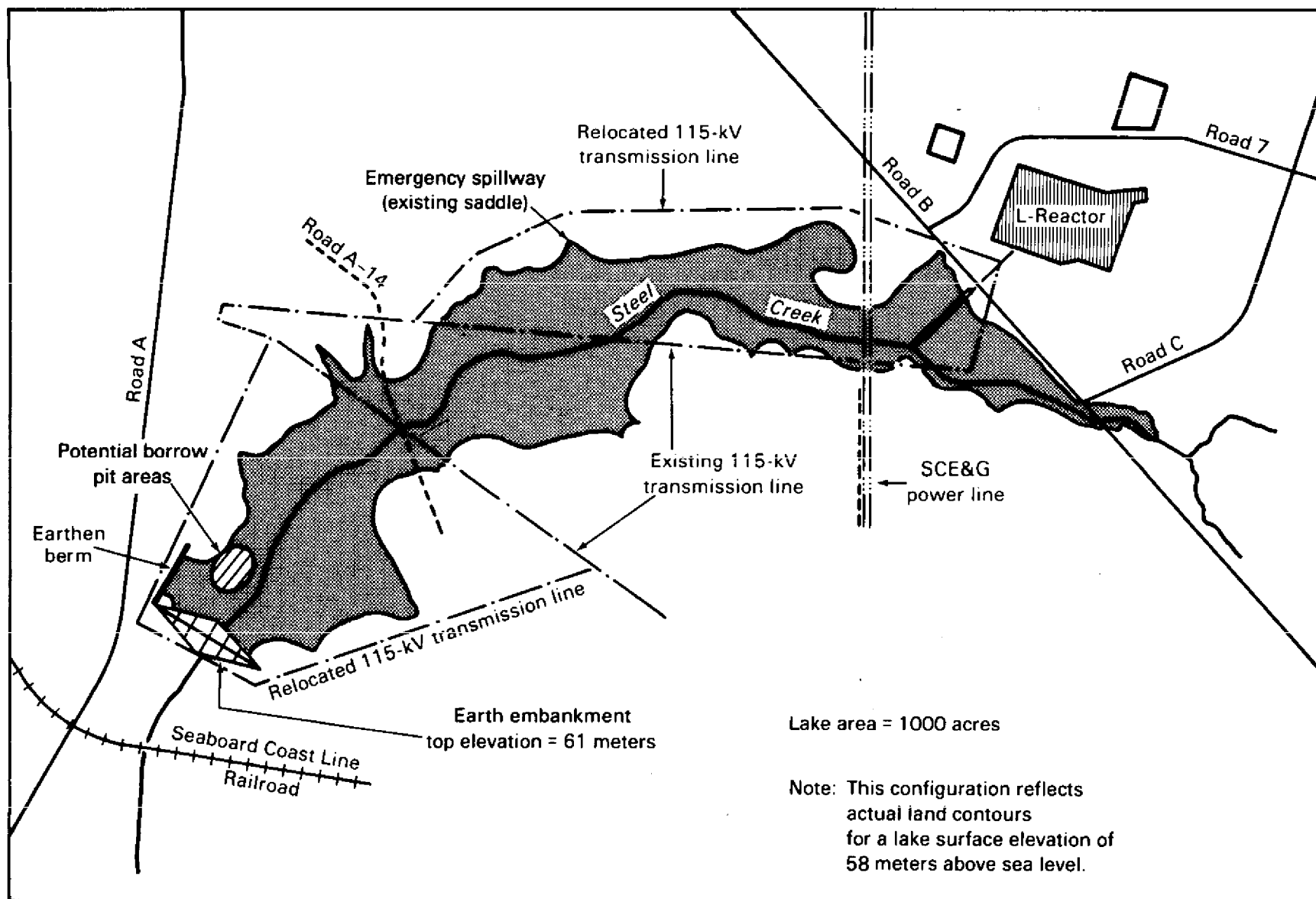


Figure 4-44. Conceptual design for 1000-acre lake on Steel Creek.

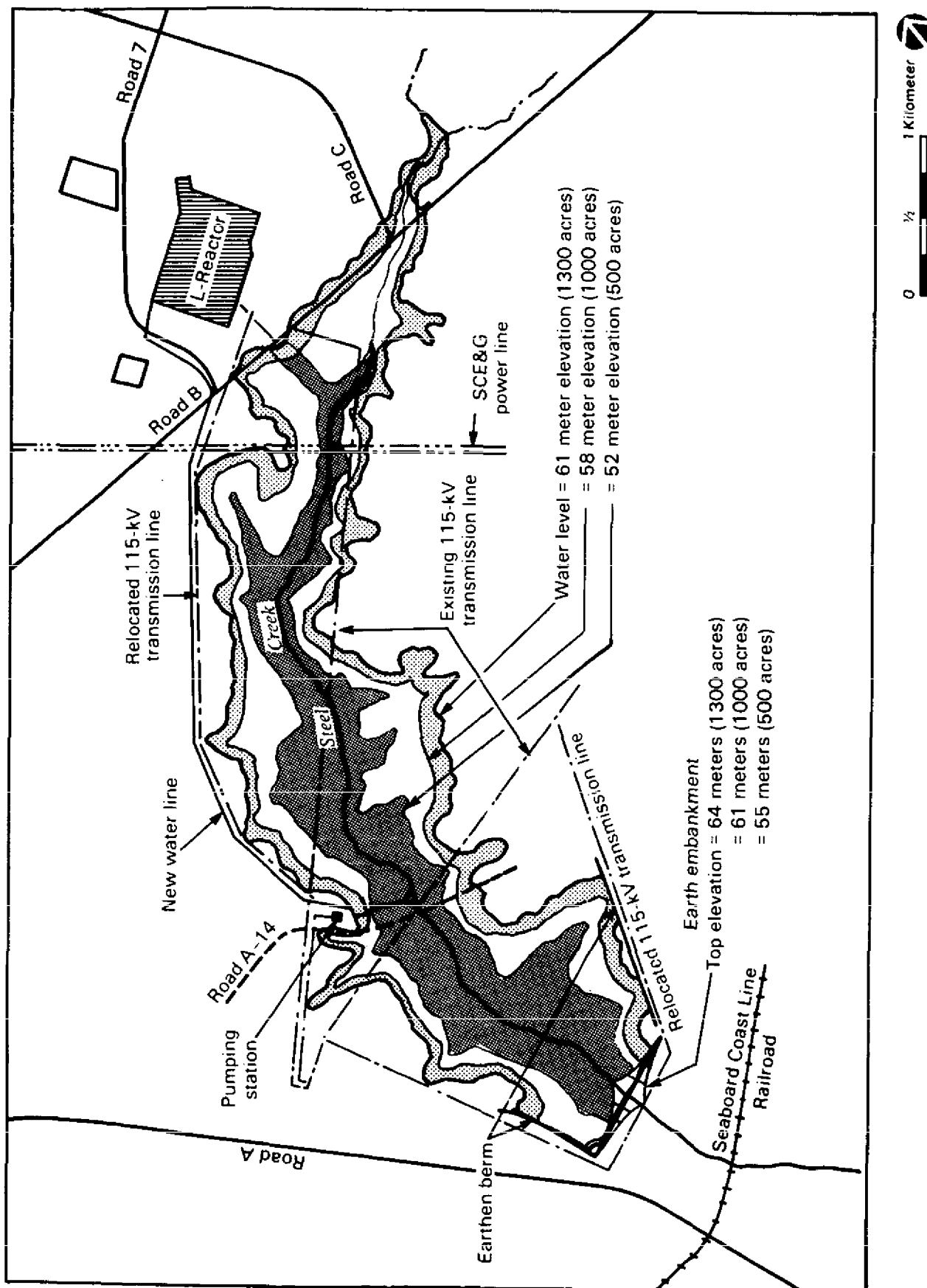


Figure 4-45. Relationship of 1000-acre lake to 500-acre lake and 1300-acre lake.

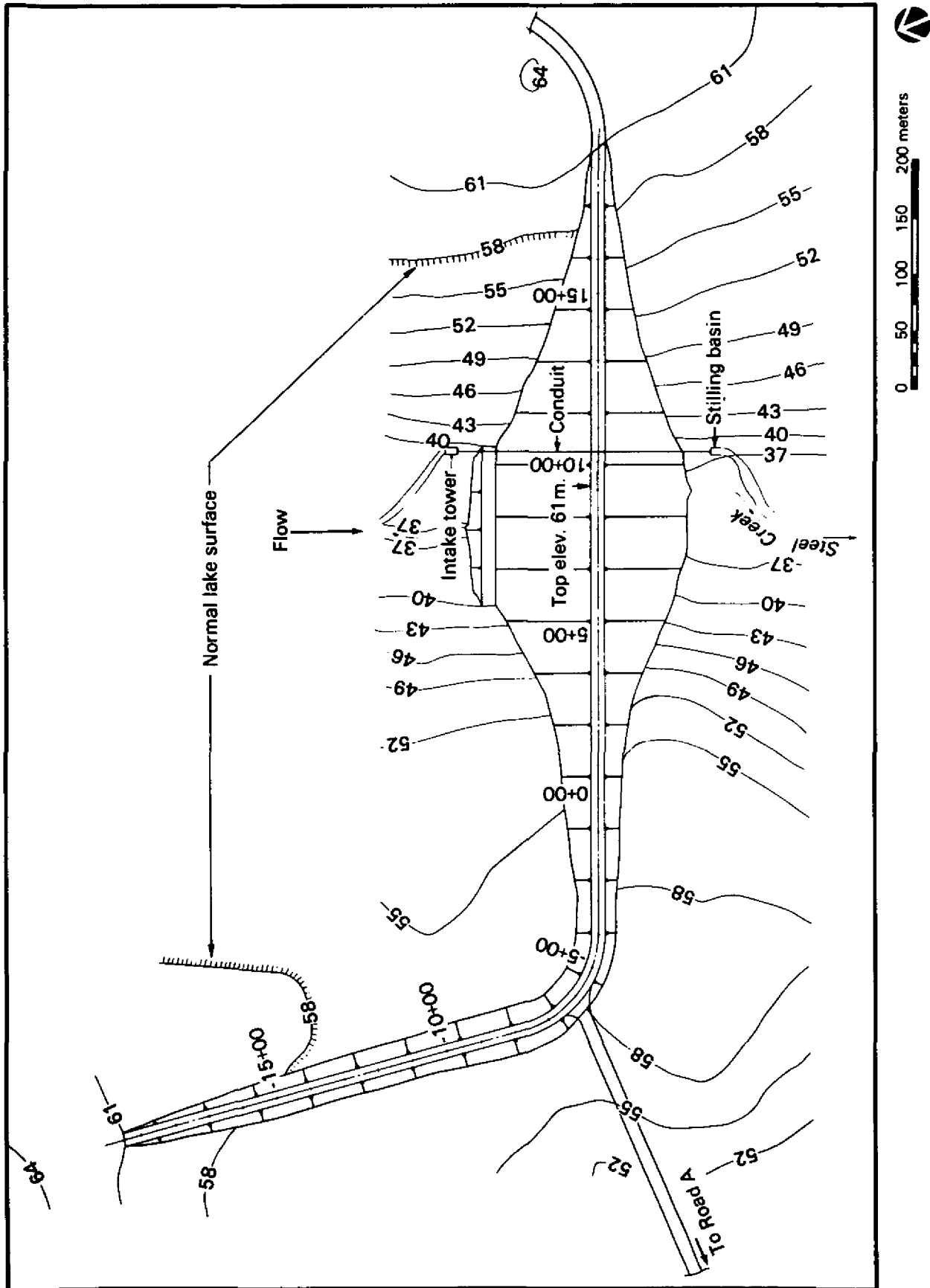


Figure 4-46. Steel Creek embankment (top view).

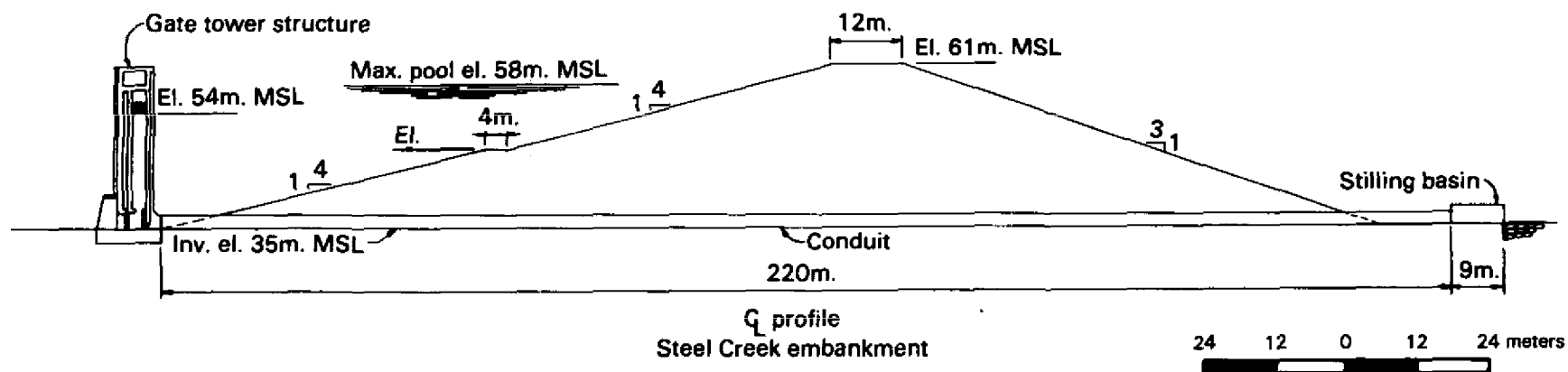


Figure 4-47. Steel Creek embankment (side view).

Hourly meteorological data for the years 1953 through 1982 and the cooling-lake thermal performance model described in Section L.2.2.1 was used in an iterative fashion to determine reactor power levels that would be required to meet the temperature criterion. The resulting average reactor power reduction was approximately 7 percent.

The heated water would be discharged into the lake through a specially designed outfall canal; it would spread over the cooler water present in the lake, enhancing the cooling efficiency (Section L.2.4.4). The surface layer would tend to exist throughout most of the lake due to the relatively small advective transport of the discharge, the depth of the lake, and the large temperature difference (between the influent and the effluent) within the lake. In addition, the discharge into the lake would be accomplished such that mixing of the discharge and resident lake water would be kept low (a desirable condition to maximize the heat flux through the water surface). Based on observations in Par Pond, as well as theoretical considerations, the surface layer in the L-Reactor cooling lake is expected to be about 1.5 meters thick. This layer would be vertically well mixed due to wind-induced turbulence. A cooler sublayer would exist beneath the surface layer. This layer would be fed by lake water returning from the cold end to satisfy the continuity requirements of discharge mixing and lake withdrawal. Accordingly, the temperatures in the deeper portions of the lake would approximate the cold end temperatures. That is, the colder sublayer temperature would range between approximately 17° and 31°C throughout the year (although some winter temperatures might be as low as 14°C, as inferred from the 30-year data base and thermal modeling).

Thermal modeling was also performed to calculate the percentage of the lake surface area having a given temperature for each season of the year. Water in the coldest 50 percent of the lake area is expected to exhibit temperatures that range from about 14°C to 23°C in the winter and from about 31°C to 32°C in the summer. Figure 4-48 shows the estimated summer isotherms in the surface layer of the 1000-acre lake. The shaded zone represents the area of the lake's surface that will be below 32.2°C.

4.5.1.2.3 Lake operation

During construction of the embankment, streamflow would be carried through the work area in a temporary metal conduit laid parallel to the outlet works conduit. An upstream cofferdam, with a crest at elevation 43 meters above mean sea level, would divert the water into the metal conduit and protect the work site. A low downstream cofferdam would protect the site from rising tailwater. This diversion configuration would provide protection from a storm with a recurrence interval of between 25 and 50 years.

Following completion of the reconfigured discharge canal, outlet works, and embankment, the outlet gates would be closed and the pool elevation of the lake would be allowed to rise to the design elevation of 58 meters above mean sea level. Assuming a constant inflow of about 11 cubic meters per second of Savannah River water from L-Reactor, 0.45 cubic meter per second from P-Reactor, and 0.62 cubic meter per second Steel Creek base flow, approximately 30 days would be required to fill the lake. As impoundment of the lake occurred, the response of the embankment would be monitored to verify design. Flow would be maintained down Steel Creek below the embankment during filling. Lake filling would be completed before startup of L-Reactor.

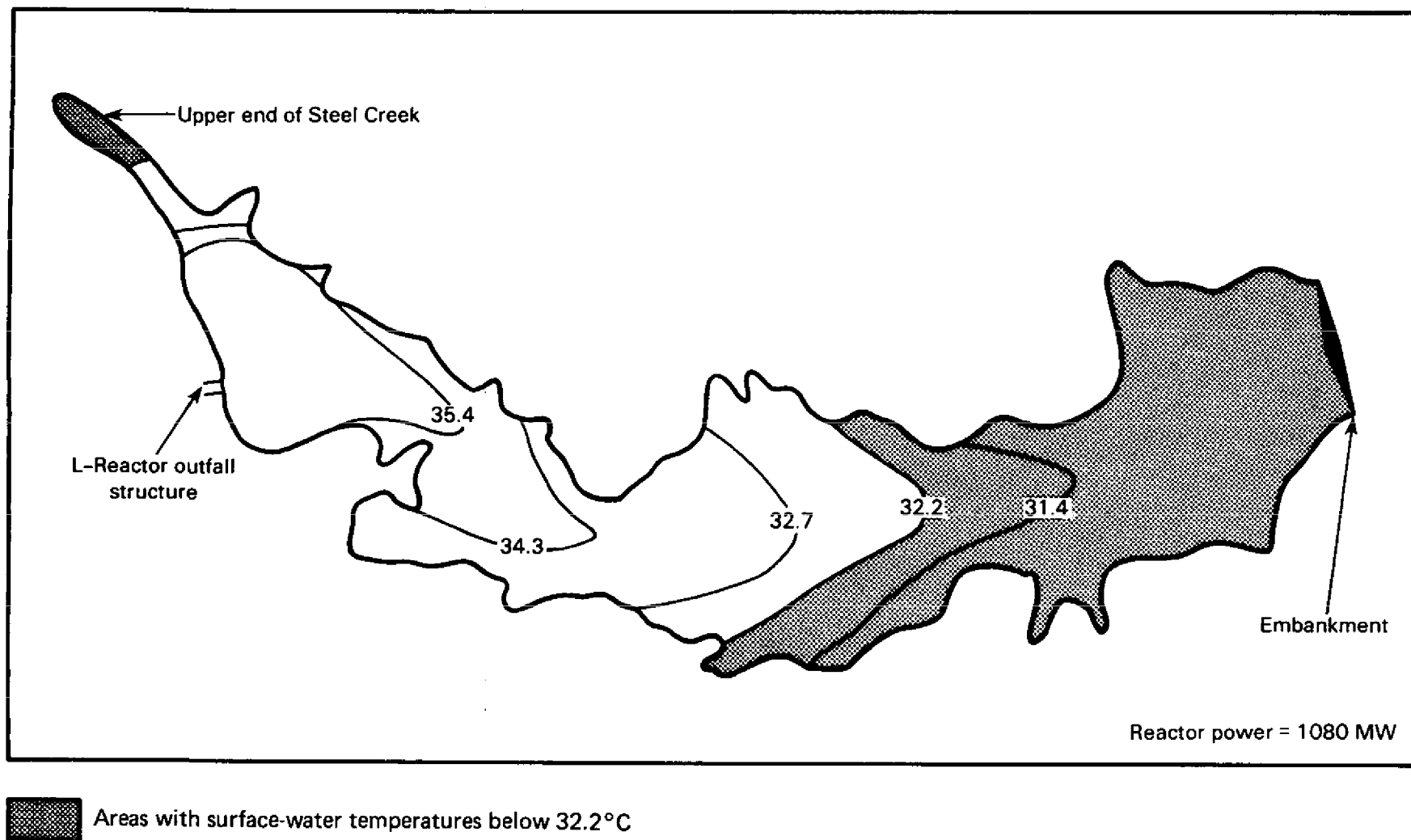


Figure 4-48. Estimated isotherms for the 1000-acre lake (summer).

Cooling-water and lake discharge flows, typically entering the outlet works at a depth of 2 to 4 meters below the lake surface, would be managed to maintain a balanced biological community in the lake and in Steel Creek and swamp. Reactor cooling-water flow variations and lake discharge management would restrict water level fluctuations to assure a healthy aquatic macrophyte population in the lake. The development of shoreline refuge areas would also enhance this macrophyte population, which would provide the necessary habitat for growth and reproduction of certain fish and macroinvertebrates necessary to maintain a balanced biological community (see Section L.4.1.1.2).

Downstream flows would be maintained constant throughout reactor operating periods, except during periods of extreme rainfall. During short reactor outages occurring within the spring spawning period, the flow at Road A would be controlled to about 3 cubic meters per second, thereby maintaining good spawning habitat. The remainder of the year, flow in Steel Creek at Road A during shutdown periods would be maintained at about 1.5 cubic meters per second, providing opportunities for fish to move freely from the base of the embankment to the Savannah River swamp.

If long reactor outages should occur during the spawning period, flow would be maintained at a rate of about 3 cubic meters per second. For long outages at other times, only base flow conditions would occur in Steel Creek.

4.5.1.2.4 Relocation of existing facilities

The construction of the 1000-acre lake would require the relocation of a 115-kilovolt electric transmission line belonging to the South Carolina Electric and Gas Company (SCE&G) and two 115-kilovolt electric transmission lines and buried supervisor control and relay cable lines that serve the L- and P-Areas. The SCE&G line could be raised from existing wooden poles onto two new tall towers in its present alignment. However, the two SRP lines would have to be rerouted around the lake because of the buried cable and the width of the lake at those points. Also, two new SCE&G transmission lines presently being designed by that company would be constructed such that they would not interfere with the 1000-acre lake.

Road A-14 would be abandoned wherever it would become inundated by the lake. The access road across the embankment would begin at Road A west of the lake and be extended northeast from the east end of the embankment along a ridge to connect with Road A-14 east of the lake. This road would parallel one of the relocated SRP transmission and buried cable lines. Approximately 600 meters of Road B and 100 meters of Road C would be raised a maximum of 3 meters on their existing roadbeds at their intersection.

4.5.1.3 Disassembly-basin water purge

The use of the L-Reactor seepage basin is the preferred alternative. As noted in Section 4.4.3, deionized and filtered purge water from the disassembly basin can be disposed of by discharge to the L-Reactor seepage basin, by evaporation, or by direct discharge to Steel Creek. Another alternative would be to detritiate the moderator (Section 4.4.5). On the bases of person-rem avoided and of the cost per person-rem avoided, the use of the L-Reactor seepage basin

is the preferred alternative for the disposal of disassembly purge water. DOE will continue to study and evaluate moderator detritiation.

The use of the L-Reactor seepage basin would result in eventual discharges to the cooling lake, not Steel Creek. The use of the cooling lake is expected to increase the ground-water travel time from about 18 years (direct discharge) to about 21 years. The radiological effects from the discharge of radionuclides, principally tritium (Table 4-11), from the seepage basin to the cooling lake are listed in Table 4-61 and in Section 4.4.6.2.

In accordance with the DOE and State of South Carolina Memorandum of Understanding of April 27, 1983, DOE will, on a continuing basis, provide the State with data showing its compliance with EPA radionuclide standards, and will continue an expanded program of monitoring and study of ground-water impacts at SRP. Sections 6.1.6 and F.6 describe DOE's commitments on SRP ground-water protection, the evaluation of seepage-basin use on a sitewide base, and a separate NEPA review of the SRP ground-water protection plan.

4.5.1.4 186-Basin sludge disposal

Batch discharge to the 1000-acre lake is the preferred alternative. Section 4.4.4 evaluates several methods for the disposal of sediment that settles from Savannah River water as it passes through the 186-Basin at L-Reactor. Methods considered included batch discharge (the reference case), land application, borrow-pit application, and continuous sediment suspension. Batch discharge is the preferred 186-Basin sludge disposal alternative on the basis of cost. It has been used in the past at L-Area and is currently being used at the other operating reactor sites. DOE will continue to study this method, in accordance with the December 15, 1983, NPDES permit issued by the State of South Carolina. During the batch discharge of settled sediment at L-Reactor and other reactor sites, composite samples of the effluent would be measured daily for total suspended sediment concentrations; the results of these measurements would be reported to SCDHEC in early 1985.

In combination with the preferred cooling-water alternative, some suspended sediment from the batch discharge of 186-Basin sludge would settle out and deposit on the bottom of the cooling lake. This deposition is expected to be a small fraction of the sediment that would be deposited in the basin from the stream flow above L-Reactor and from suspended material carried in the cooling water after it has passed through the 186-Basin and reactor heat exchangers. Siltation from these sources is not expected to have appreciable effects on the performance of the cooling lake.

4.5.2 Impacts due to construction and mitigation

This section characterizes the expected effects due to construction of the 1000-acre lake. No construction activities are required by the other preferred alternatives.

Table 4-61. Expected average annual liquid radioactive releases from L-Reactor operation
(curies per year)

Radionuclide	1st year of operation				10th year of operation			
	To 1000-acre lake	To seepage basin	To 1000-acre lake from ground water ^a	Total to 1000-acre lake	To 1000-acre lake	To seepage basin	To 1000-acre lake from ground water ^b	Total to 1000-acre lake
H-3	3.6×10^2	1.1×10^3	--	3.6×10^2	3.6×10^3	1.1×10^4	6.0×10^3	9.6×10^3
P-32	--	1.2×10^{-3}	--	--	--	1.2×10^{-3}	--	--
S-35	--	9.5×10^{-3}	--	--	--	9.5×10^{-3}	2.9×10^{-8}	2.9×10^{-8}
Cr-51	--	1.8×10^{-1}	--	--	--	1.8×10^{-1}	--	--
Co-58,60	4.5×10^{-2}	3.7×10^{-4}	--	4.5×10^{-2}	4.5×10^{-2}	3.7×10^{-4}	2.1×10^{-4}	4.5×10^{-2}
Sr-89	--	7.0×10^{-5}	--	--	--	7.0×10^{-5}	--	--
Sr-90	1.6×10^{-4}	2.0×10^{-4}	--	1.6×10^{-4}	1.6×10^{-4}	2.0×10^{-4}	--	1.6×10^{-4}
Y-91	--	5.1×10^{-3}	--	--	--	5.1×10^{-3}	--	--
Zr-95	--	1.1×10^{-2}	--	--	--	1.1×10^{-2}	--	--
Ru-106	--	3.4×10^{-4}	--	--	--	3.4×10^{-4}	1.7×10^{-5}	1.7×10^{-5}
Sb-125	--	8.0×10^{-3}	--	--	--	8.0×10^{-3}	2.6×10^{-3}	2.6×10^{-3}
I-131	--	6.9×10^{-3}	--	--	--	6.9×10^{-3}	--	--
Cs-134	--	5.1×10^{-3}	--	--	--	5.1×10^{-3}	--	--
Cs-137	4.1×10^{-4}	4.4×10^{-2}	--	4.1×10^{-4}	4.1×10^{-4}	4.4×10^{-2}	--	4.1×10^{-4}
Ce-144	--	1.9×10^{-2}	--	--	--	1.9×10^{-2}	3.8×10^{-4}	3.8×10^{-4}
Pm-147	--	2.8×10^{-3}	--	--	--	2.8×10^{-3}	8.8×10^{-4}	8.8×10^{-4}
Unidentified beta-gamma ^d	1.1×10^{-1}	8.9×10^{-2}	--	1.1×10^{-1}	1.1×10^{-1}	8.9×10^{-2}	--	1.1×10^{-1}
Unidentified alpha ^e	2.0×10^{-5}	3.2×10^{-4}	--	2.0×10^{-5}	2.0×10^{-5}	3.2×10^{-4}	--	2.0×10^{-5}

^aOutcrop activities will not occur during the first 4 years of reactor operation; see Table B-19 and Section F.2.10.

^bOutcrop activities after 15 years of L-Reactor operation. Due to long transport times in ground water, strontium-90, cesium-134, cesium-137, and plutonium-239 do not reach outcrop in the 15-year period.

^cThirty percent of this tritium is expected to evaporate.

^dAssumed to be strontium-90.

^eAssumed to be plutonium-239.

4.5.2.1 Socioeconomics and land use

For the preferred alternative, an additional 550 temporary construction workers would be required for the earth moving and dam building necessary to construct the 1000-acre lake. This estimate is based on a comparison with similar projects and on the assumption that a normal construction schedule would be followed. Minor impacts to local communities and services could be expected from immigrating workers; economic benefits are expected to be minor in comparison to those caused by the L-Reactor and the total SRP operating workforce.

The total economic benefit of the L-Reactor restart using the reference case is 400 direct and indirect job opportunities, about \$25 million in direct and indirect annual income and payroll, and \$3 million in direct annual expenditures on materials and services. The preferred cooling-water alternative case would increase these benefits in the short term during embankment construction.

The 1000-acre cooling lake would be entirely within the present SRP area boundaries. Land use within the SRP area would be altered, in that 1000 acres would be inundated to become a cooling lake and the previous land uses as forest land and bottom land would be interrupted. The 1000 acres would include 225 acres of wetlands in the Steel Creek Corridor and 775 acres of uplands. Timber of commercial value would be harvested and removed from the site in accordance with SRP Forest Management Program. An additional area (about 133 acres) would be cleared for road and utility access relocation.

The timber which would be harvested consists of pine saw timber, pine pulp wood, hardwood saw timber, and hardwood pulp wood. The timber value and annual growth are summarized in Table 4-62. The anticipated value from harvesting the timber is \$950,000. The annual loss in timber productivity is projected to be \$44,000. This impact is not amenable to mitigation.

Table 4-62. Timber value and annual growth

Type of timber	Present volume/value			Annual growth	
	Volume (1000 board feet)	Cords	Value (\$1000)	Volume (%)	Value (\$1000)
Pine, saw timber	5058	--	715	4	28
Pine, pulp wood	--	4326	102	8	12
Hardwood, saw timber	2550	--	128	3	4
Hardwood, pulp wood	--	3384	5	6	.3
Totals	--	--	950	--	44

4.5.2.2 Relocation of existing facilities

SCE&G would design and relocate its own transmission lines. The design and construction of the relocation of the SRP roads and transmission and control cable lines would be performed by the Du Pont Engineering Department. The U.S. Forest Service would administer all clearing for these relocations as well as clearing for the lake area.

4.5.2.3 Site preparation

Clearing

All areas upstream from the embankment and less than 58 meters above mean sea level would be cleared of second growth pine and hardwood to provide for the 1000-acre lake area. All marketable timber from this area and from the road and transmission corridors would be cut, removed, and sold under the supervision of the Forest Service. Timber and vegetation in any area flooded by Steel Creek waters since 1954 might contain low-level radioactivity and would not be marketable. Procedures for the removal and disposition of such material would be developed and approved before construction started. Underbrush and scrap, except from timber cutting outside the area flooded by Steel Creek since 1954 except around some of the shoreline area would be piled and burned. Stumps would be removed under all embankment areas but not from the area within the lake.

Foundation preparation

Areas to be covered by the embankment, inlet and outlet works, or roadways would be grubbed and stumps would be removed and burned. All topsoil would be stripped and stockpiled for use on the finished grade for turf establishment. It might be necessary to excavate unconsolidated sediments from the area under the dam to a depth of between 3 and 15 meters to expose a tight clay formation to which the embankment could be sealed. Approximately 600,000 cubic meters of unsuitable material could be removed from the embankment site before 1.2 million cubic meters of borrow fill and rip-rap would be placed to form the embankment. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the jurisdictional wetlands upstream of the embankment, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

Abandoned well survey and sealing

Research is currently underway to determine how many wells were constructed within the lake area before Government acquisition of the SRP property. All of these wells would be sealed before the lake begins filling to reduce the chance of affecting ground-water quality.

In March 1984, a survey team from the Furman University Department of Geology performed a field survey of this portion of the Steel Creek watershed. Twenty old possible well sites were identified in this area, 11 of which were

found to lie within the boundaries of the 1000-acre lake. The sites vary from shallow open depressions to deep cased and screened wells. Several of these might be grave sites or archeological sites rather than wells.

Each site identified, as well as any others drilled or located during construction of the 1000-acre lake, would be sealed by filling from bottom to top with sand-cement or concrete in accordance with the South Carolina Primary Drinking Water Regulations, Section R 61-58.2 C (14), "Permanent Well and Test Hole Abandonment." All information relative to each site (e.g., exact plant coordinate location, depth, diameter) would be recorded and submitted to SCDHEC.

4.5.2.4 Embankment construction

The construction of the earthen embankment and water diversion system for the lake would cause some temporary increases in suspended solids in Steel Creek. Suitable precautions would be taken (1) during the construction operations necessary to establish a foundation for the embankment, and (2) during emplacement of the fill to ensure that undue silt and debris loads do not move downstream from the construction site. Turbidity screens could minimize impacts to downstream areas.

Borrow pits for similar quantities of suitable materials have been identified in the past for construction at the Savannah River Plant, and have been controlled in an environmentally acceptable manner. About 90 percent of the fill material for the embankment would probably come from a borrow pit that would be submerged when the lake is filled (Section L.2.4.7). A second potential borrow site would not be inundated. A small volume of material might be taken from this location, which would result in the loss of about 5 acres of upland habitat.

The number and routing of access roads for construction have been carefully considered to minimize adverse environmental impacts. An estimated 33 acres of upland habitat outside the area to be inundated would be altered by the construction of access roads. The reconstruction of existing roads would not result in the alteration of any uplands because they would utilize the existing roadbed. The rerouting of powerline and buried cable rights-of-way would cause the loss of an additional 100 acres of upland habitat.

Spoil piles of the size expected for this alternative have been developed for past construction activities at the Savannah River Plant and have met the necessary environmental control requirements. Spoil from any excavation in the former floodplain of Steel Creek would be monitored for radioactive materials; any spoil containing radioactivity would be disposed of as discussed in Section L.2.4.2.2.

4.5.2.5 Ecology

There would be two principal sources of potential impact to the ecology of the area: (1) the construction of the embankment and associated appurtenances, and (2) the inundation by the lake.

The filling of the cooling lake would inundate between 225 acres of wetlands and 775 acres of uplands in the Steel Creek corridor. The vegetation in this area consists primarily of forested (73 percent) and scrub-shrub (24 percent). The wetland areas are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

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4.5.2.6 Water quality

The potential impacts to water quality from construction would be erosion and sedimentation; these potential impacts would be mitigated as described in Section 4.5.2.9.

4.5.2.7 Air quality and noise

About 400 to 550 acres of upland forest would be cleared. Trees of commercial value would be harvested and removed from the site in accordance with the SRP Forest Management Program. Open burning would be employed for disposal of forest slash cleared from the site. Clearing and burning would progress in reasonably sized units of a few acres to minimize local dust and smoke. The nearest roadways to the lake would be SRP Road B (less than 30 meters) and Highway 125 (1 kilometer). Traffic could be rerouted from Road B if necessary during the burning of slash material. Because of its distance from the construction site, Highway 125 would not be affected. Burning would result in some releases of particulates and gases into the atmosphere, but releases would be local and generally short-lived. Offsite effects are not expected since the nearest location to the SRP site boundary from the lake would be approximately 8 kilometers.

Not all the lake would be grubbed and burned. About 200 acres of lake bottom near the shoreline would be maintained with the stumps in place as habitat for aquatic organisms. Other burnable slash might also be used to construct submerged habitat attraction structures, thus reducing the need to burn all material at the site. Temporary construction roads, laydown areas, and spoil areas would be graded, grassed, wetted, or sprayed with tackifiers as needed to reduce local dust. As much as possible, the roads would be designed to become permanent access roads when the project was completed, thus reducing the impacts of temporary haul roads.

The cooling lake construction site is in a forest area that is relatively remote from human habitation. Noise from construction, primarily from tree-cutting and earth-moving equipment, would have insignificant offsite environmental effects because of the remoteness of the site and the muffling effect of intervening forests. Members of the public using SC Highway 125 would not be in the immediate vicinity of noisy equipment and would have only brief exposure. Effects of this exposure would be insignificant. Noise levels from lake-site construction in nearby L-Area, the nearest occupied onsite facility, are expected to be well within clearly acceptable standards (62 decibels). Operators

of noisy construction equipment would wear protective equipment in accordance with Du Pont standards (where applicable) and OSHA regulations. Most other workers in the area would be exposed to high noise levels only intermittently, but protective equipment would be provided when the exposure could be expected to be sustained. No impulsive or impact noises in excess of acceptable standards would be expected.

4.5.2.8 Historic/archeological

Four historic sites and one prehistoric site in the Steel Creek terrace and floodplain system (Figure 3-3) have been determined to be eligible for inclusion in the National Register of Historic Places. No direct impacts are expected to the prehistoric site or to three of the historic sites because they would be below the embankment and outside the area affected by high-water flow conditions. One historic site area would be inundated when the lake was filled. These impacts would be mitigated as described in Section 4.5.2.9.

In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described as of ephemeral quality and not eligible for nomination to the National Register of Historic Places.

Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation would be affected. As of May 7, 1984, two potentially significant sites had been identified. DOE is developing data recovery plans and continuing the consultation process with SHPO and ACHP. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation would be completed prior to restart (Hanson, 1984). The study results, determination of the eligibility of potential sites, and the development of a mitigation plan are being coordinated with the SHPO and ACHP.

4.5.2.9 Construction impact mitigation

Historic/archeological site mitigation

A monitoring and mitigation plan has been developed to ensure the preservation of the resources at the four sites below the dam, and the plan has been approved by the South Carolina State Historic Preservation Officer (SHPO) (Du Pont, 1983).

A resource recovery plan has been developed by the University of South Carolina Institute of Archeology and Anthropology for the one historic site (38 BR 288) located within the proposed lake area. This mitigation plan has been approved by the SHPO and the Advisory Council on Historic Preservation (ACHP) (Lee, 1982), which concurred that this mitigation plan would result in no adverse impacts to National Register properties.

Ecological mitigation

The Department of Energy is working with the Department of the Interior to perform a Habitat Evaluation Procedure (HEP). The HEP will identify the value of habitat to be gained or lost with implementation of the preferred cooling-water mitigation alternative for use in assessing further mitigation. If required, DOE will implement additional mitigative measures that might be identified through the HEP process, dependent on Congressional authorization and appropriation.

The endangered wood stork forages at the Savannah River Plant but does not breed on the site. The feeding individuals have been observed to be from the Birdsville Rookery, some 50 kilometers away. Feeding occurs in the swamp away from the proposed lake; it could be affected by raised water levels of the Steel Creek delta if the L-Reactor cooling-water flow is discharged through the proposed lake. DOE initiated informal consultation with the Fish and Wildlife Service (FWS) in July 1983 and in March 1984 as required by Section 7 of the Endangered Species Act. DOE has also initiated the formal consultation process by providing a Biological Assessment to FWS for a Biological Opinion (Sires, 1984a). While DOE concludes that the operation of L-Reactor would affect foraging habitat near the Steel Creek delta, the construction activities associated with Phase II of the NPDES permit to control the acidity of releases from the 400-area powerhouse ash basins would improve the quality of the foraging habitat in the Beaver Dam Creek area, assuring the continued availability of this habitat. Therefore, the loss of foraging habitat in the Steel Creek area would not jeopardize the continued existence of the wood stork. Any additional mitigation measures needed would be determined either as part of the HEP study or as part of this consultation process.

Water-quality mitigation

The lake construction activity would include an Environmental Protection Plan, which would include several measures designed to mitigate water-quality impacts.

Earthwork brought to final grade would be protected as soon as practicable. All earthwork would be planned and conducted to minimize the duration of exposure of unprotected soils. Except in instances where the constructed feature obscures borrow areas and waste material areas, these areas would not initially be cleared in total. Clearing of such areas would progress in reasonably sized increments as needed.

Such methods as necessary would be utilized to effectively prevent erosion and control sedimentation, including but not limited to the following:

1. Retardation and control of runoff. Runoff from the construction site would be controlled by construction of diversion ditches, benches, and berms to retard and divert runoff to protected drainage courses.
2. Sediment basins. Sediment from construction areas would be trapped in temporary or permanent sediment basins in accordance with design plans. The basins would accommodate the runoff of anticipated storms. After each storm the basins would be pumped dry and accumulated sediment would be removed as necessary to maintain basin effectiveness.

Overflow would be controlled by paved weir or by vertical overflow pipe, draining from the surface. The collected topsoil sediment would be reused for fill on the construction site, and/or conserved (stock-piled) for use elsewhere. Effluent quality monitoring programs would be required.

Temporary erosion and sediment control measures such as berms, dikes, drains, sedimentation basins, grassing, and mulching would be used until permanent drainage and erosion control facilities were complete and operative.

Borrow areas and spoil-storage areas would be managed to minimize erosion and to prevent sediment from entering nearby water courses or lakes. Temporary excavations and embankments for work areas would be controlled to protect adjacent areas from despoilment.

Solid wastes (excluding clearing debris) would be placed in containers which would be emptied on a regular schedule. All handling and disposal would be conducted to prevent contamination. Chemical waste would be stored in corrosion-resistant containers, removed from the work area, and disposed of in accordance with Federal, State and local regulations.

Construction activities would be kept under surveillance, management, and control to avoid pollution of surface and ground waters. The following special management techniques would be implemented to control water pollution: (1) wastewaters derived from construction activities would not be allowed to leave the site; these wastewaters would be collected in retention ponds where suspended material could be settled out or the water evaporated so pollutants would be separated from the water; (2) the operation would be planned to minimize adverse impacts of dewatering, removal of cofferdams, and excavation, and to limit the impact of water turbidity on the habitat for wildlife and impacts on water quality for downstream use; (3) stream crossings would be controlled during construction; crossings would provide for movement of materials or equipment which do not violate water pollution control standards of the Federal, State, or local government; (4) all water areas affected by construction activities would be monitored; (5) construction activities would be kept under surveillance, management, and control to minimize interference with, disturbance to, and damage of fish and wildlife.

Air emissions and noise control

The construction Environmental Protection Plan would also require measures to mitigate air emissions and noise. Construction activities would be kept under surveillance, management, and control to minimize pollution of air resources. All activities, equipment, processes, and work performed would be in strict accordance with applicable requirements.

The following special management techniques would be implemented to control air pollution by the construction activities:

1. Dust particles, aerosols, and gaseous byproducts from all construction activities, processing and preparation of materials would be controlled at all times, including weekends, holidays, and hours when work is not in progress.

2. Particulates that could cause the air pollution standards to be exceeded or that could cause a hazard or a nuisance would be controlled at all excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and all other work areas within or outside the project boundaries. Sprinkling, chemical treatment of an approved type, light bituminous treatment, or other methods would be utilized to control particulates in the work area. Sprinkling would be repeated at such intervals as to keep the disturbed area damp. Particulate control would be performed as the work proceeded and whenever a particulate nuisance or hazard occurred.
3. Hydrocarbons and carbon monoxide emissions from equipment would be controlled to Federal and State allowable limits at all times.
4. Odors would be controlled at all times for all construction activities, processing and preparation of materials.
5. Air at all areas affected by the construction activities would be monitored.

Construction activities would be kept under surveillance and control to minimize damage to the environment by noise. Methods and devices would be used to control noise emitted by equipment to the levels shown in the COE, Savannah District Safety Manual (COE, Savannah District, 1981a).

4.5.3 Nonradiological impacts due to normal L-Reactor operation

This section characterizes the expected nonradiological and radiological effects due to the normal operation of L-Reactor with the system of preferred mitigation alternatives. Nonradiological effects include those that might result from changes in land use, an increased workforce, the withdrawal and discharge of cooling water, the discharge of liquid and atmospheric chemical effluents, and the disposal of solid nonradioactive wastes. Radiological effects include those that might result from airborne and liquid radionuclide releases, the disposal of radioactive wastes, and the resuspension and transport of radio-cesium and cobalt-60 in Steel Creek.

4.5.3.1 Land use and socioeconomics

The resumption of L-Reactor operation with the preferred alternatives is not expected to produce any additional land-use impacts. Operational employment for L-Reactor, which began in 1981, peaked at about 400 employees in mid-1983 and is expected to decrease to 350 by mid-1984, or about 4 percent of the current workforce at the Savannah River Plant (Du Pont, 1982b). Essentially all the operating workforce for L-Reactor has been hired and resides in the SRP area; therefore, no additional impacts are expected to local communities and services due to in-migrating workers.

L-Reactor operation is expected to have annual total local expenditures on materials and services of approximately \$3 million and a total payroll and overhead expenditure of about \$21 million. These expenditures are expected to result in the creation of about 50 regional job opportunities. In addition, these expected expenditures are anticipated to produce an additional direct and indirect income of another \$3 million. The total economic benefit to the SRP region during L-Reactor operation would amount to at least 400 direct and indirect job opportunities, about \$25 million in direct and indirect annual income and payroll, and \$3 million in direct annual expenditures on materials and services.

These contributions to the local economy would help pay for public services directly through income, property, and license taxes and user fees and help indirectly through sales taxes on goods and services. The benefits provided by the project would help offset the small increase in demands for local services that it generates.

A supplement to the approved mitigation plan protecting the four historic and one prehistoric sites shown in Figure 3-3 will be developed by DOE and submitted to the SHPO and ACHP for approval. This supplement would protect new sites eligible for nomination to the National Register of Historic Places.

4.5.3.2 Surface-water usage

With the 1000-acre once-through cooling lake, L-Reactor operation would withdraw about 11 cubic meters of water per second from the Savannah River. This would be less than 4 percent of the average flow and 7 percent of the 7-day, 10-year low flow of 295 and 159 cubic meters per second, respectively. Because little L-Reactor cooling water would be consumed, essentially all water withdrawn from the river would be returned to the river after passing through the L-Reactor heat exchangers and the Steel Creek system. According to Neill and Babcock (1971), the estimated consumptive water use by L-Reactor is expected to be about 1.25 cubic meters per second.

Withdrawal of cooling water for L-Reactor operation would affect the aquatic ecology of the Savannah River by (1) the entrainment in the cooling water of aquatic organisms (predominantly fish eggs and larvae) smaller than the screen mesh in the intake system, and (2) the impingement of aquatic organisms (primarily fish) on the intake screens. The impacts due to entrainment are estimated to be 7.7×10^6 additional fish eggs and 11.9×10^6 additional fish larvae annually. The impingement impact is estimated to be 16 fish per day (Section 4.1.1.2).

4.5.3.3 Ground water

The withdrawal of ground water for L-Reactor would be about 0.94 cubic meter per minute. The ground-water withdrawal from the Tuscaloosa is projected to decrease when L-Reactor operation resumes (excluding incremental pumping in support of L-Reactor) compared to 1982 pumping; water levels are expected to

rise as a new equilibrium piezometric surface is established at SRP and neighboring areas. At Jackson and Talatha, water levels are projected to increase by about 0.5 and 0.4 meter, respectively, if sitewide pumping decreases to 20.5 cubic meters per minute. However, pumping at L-Area would draw down the water in the Tuscaloosa locally, and thereby reduce the upward head difference between the Tuscaloosa and Congaree to about 1.4 meters beneath the L-Reactor seepage basin. The withdrawal of ground water from the Tuscaloosa will not affect water levels in overlying aquifers because of the thick Ellenton clay unit and the basal Congaree clay. Important clay layers, principally the green clay, beneath the L-Reactor seepage basin will tend to protect the Congaree and Tuscaloosa Aquifers; any contaminants that might reach these aquifers would flow beneath the SRP to the Savannah River in 76 to 250 years, respectively, and will not affect offsite ground-water users (Section 4.1.1.3).

Impounded water for a cooling lake would cause a local ground-water mound in the water-table aquifer, which would tend to increase the travel time from the L-Reactor seepage basin to seepage springs near the lake's shore from about 18 years to 21 years. This effect of the lake would dissipate with depth and would be expected to have a small effect on water levels in the McBean Formation. The green clay confining unit separates the McBean from the underlying Congaree Formation. It would prevent the increased head associated with a cooling lake from impacting the head differential between the Tuscaloosa and Congaree Formations. It is also an important barrier to the migration of contaminants from near-surface to lower hydrostratigraphic units. In the Separations Areas and near the Central Shops, the green clay (about 2 to 3 meters thick) supports a head difference of about 21 to 24 meters between the McBean and Congaree Formations. Based on water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin, the green clay has effectively protected the Congaree ground water from contamination seeping into the ground (Marine, 1965). In the L-Area, the green clay is about 7 meters thick. At the Par Pond pumphouse, along the strike of the McBean and Congaree Formations, the green clay also supports a large head difference; the water pumped from the Congaree Formation shows no evidence of tritium contamination, even though tritium concentrations in Par Pond were measured at 27,000 picocuries per liter.

Due to the sandy soil in the area of the natural saddle that would serve as the emergency spillway (Figure 4-44), some seepage could occur from the 1000-acre lake to Pen Branch. A cut-off wall would be constructed in this area if seepage is a problem.

4.5.3.4 Thermal discharge

Thermal discharge from the reactor would flow into the 1000-acre lake at temperatures of 73°C or less, depending on reactor power and river intake temperatures. Reactor power, in turn, would be established by lake temperatures and meteorological conditions. As noted in Section 4.5.1.2.2, L-Reactor would be operated at the highest allowable power level consistent with the maintenance of a balanced biological community, as specified in the NPDES permit expected to be issued by SCDHEC. Initially, L-Reactor would operate to maintain 32.2°C or less in about 50 percent of the lake. Isotherms calculated for summer conditions and an average reactor power level of 1080 megawatts are shown in Figure 4-47. Similar diagrams for the other seasons are presented in Appendix L. The

expected composition of the balanced biological community is described in Appendix L.

Table 4-63 lists the estimated temperatures in Steel Creek below the lake's discharge structures for summer, spring, and winter. Projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp and the mouth of Steel Creek would be within about 1°C of ambient. In the spring, water temperatures at the Steel Creek delta would be 3°C above ambient. Water temperatures would be near ambient at the mouth of Steel Creek. These conditions would not pose any adverse impacts to aquatic and semiaquatic biota. In the winter, however, projected temperatures at Road A and points downstream would be 7°C and 9°C above historical ambient. These warmer conditions could concentrate fish at the mouth of Steel Creek. Reactor shutdowns during the winter would result in gradual heat loss in this area, which would minimize any cold shock effects. This alternative would not adversely impact access to, and the spawning of riverine and anadromous fishes in, the Savannah River swamp below the Steel Creek delta.

Table 4-63. Temperatures (°C) downstream in Steel Creek below the 1000-acre lake

Location	Summer ^a	Spring ^b	Winter ^b
Discharge temperature ^c	31	26	17
Road A	31	26	17
Swamp	31	25	15
Mid-swamp	30	22	13
Mouth of creek at river	30	22	13

^aBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of reactor. Five-day worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered to be representative of extreme temperatures for which the maintenance of a balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act.

^bBased on 30-year average values for meteorological conditions and actual power of an operating reactor.

^cThe temperature entering Steel Creek from the lake.

There would be minimal impacts in Steel Creek below the embankment. However, the flow of discharge water would have adverse impacts on between 215 and 335 acres of wetlands in the Steel Creek delta and swamp. This area, which is dominated by forested (45 percent) and scrub-shrub (36 percent) wetlands, provides foraging habitat for the endangered wood stork and American alligator. These wetlands also represent important feeding and roosting habitat for as many

as 1200 mallard and 400 wood duck. Impacts on the American alligator, mallard, and wood duck are expected to be minimal. A delta growth rate of about 1 to 2 acres per year is anticipated.

Of the 4800 breeding pairs of wood storks sighted in the United States in 1980, approximately 100 pairs were observed at the Birdsville Rookery near Millen, Georgia. The Steel Creek delta area is one of the 50 foraging sites used by the wood stork; in 1983, 100 wood storks were observed feeding in the delta, which is an important foraging habitat (Meyers, 1984). Higher water levels at the delta could potentially make this area less desirable as a foraging habitat. The total elimination of the Steel Creek delta area as a foraging habitat for the wood stork would represent the displacement of food required for fledglings. As observed in 1983, when the delta area was not available for foraging, the wood storks moved to other available foraging habitats; 1983 was a successful year for the Birdsville Rookery wood storks. The Department is going through the consultation process with the U.S. Fish and Wildlife Service, as required by the Endangered Species Act (Sires, 1981). The biological opinion to be issued by the Fish and Wildlife Service will indicate the needed mitigation measures and should agree with DOE's conclusion that the operation of L-Reactor would not affect the continued existence of this species.

Thermal impacts on the biota in the river would be minimal because water temperatures would be very close to ambient at the point the discharge flow enters the river. There would be a zone of passage for the movement of fish up and down the river past the SRP site.

The embankment and cooling lake would prevent access by riverine and anadromous fish to about 100 acres of wetlands along Steel Creek above L-Reactor. However, the only migratory fish in this reach of Steel Creek would be the American eel. Also, access to Meyers Branch would not be affected by the embankment.

Preliminary results of investigations in upper Steel Creek indicate that the macroinvertebrate community is self-sustaining and therefore unlikely to undergo significant changes as a result of the creation of the 1000-acre lake. Sixteen species of fish have also been collected in this reach of Steel Creek during two recent surveys. Most of the species are small fish that prefer stream habitats. However, because all but one of the species collected has been reported in thermal refugia (backwater or tributary stream areas) peripheral to reactor effluent streams on SRP, it is anticipated that the fish populations in upper Steel Creek would be capable of maintaining their present status in the 3- to 4-kilometer reach that would, when the reactor is operating, be isolated above the cooling lake. There would, however, undoubtedly be shifts in patterns of relative abundance. For example, the thermally tolerant mosquitofish would probably increase in abundance, and those species that prefer or can utilize lake habitats could thrive in the upper portions of the lake, where temperatures would be moderated by the inflow from Steel Creek.

4.5.3.5 Wastewater discharges

Liquid effluent discharges

With the preferred alternatives, liquid effluents to the Savannah River would have chemical characteristics similar to those of the river and would, therefore, produce no impacts.

Sanitary discharges

Sanitary wastewater would be chlorinated at a packaged treatment plant and discharged through the L-Area wastewater sewer to Steel Creek. The sanitary wastewater-treatment plant is designed for a maximum flow of 132 cubic meters per day. The treatment-plant size was selected to be adequate for the expected operating workforce. The discharge would meet NPDES permit (Du Pont, 1981a) requirements and would have not major impact on Steel Creek (Du Pont, 1982b). Sewage sludge would be transported to an existing basin near the Central Shops. Samples of sludge from similar treatment facilities indicate that it is not hazardous (Du Pont, 1982b).

Cooling-water reservoir (186-Basin)

The 95-million-liter cooling-water processing basin (186-Basin) would be cleaned annually during periods of reactor shutdown to remove accumulated solids. About 110 metric tons of the 5530 metric tons of suspended solids that would enter the 186-Basin annually would be deposited in the basin. This sediment would be flushed to Steel Creek over a period of several days. During flushing, the suspended solids concentrations in the effluent would be about 60 to 160 parts per million. This annual operation has been performed many times at the other reactors with no evidence of detrimental impact. Most of the suspended solids released from the 186-Basin would settle in the streambed before reaching the swamp (Kiser, 1977; Geisy and Briese, 1978; Du Pont, 1981a; Ruby et al., 1981). When L-Reactor discharges resume (at about 11 cubic meters per second), the resuspension of some of this settled sediment could contribute a small amount of material to the delta, which is expected to grow at a rate of about 1 to 2 acres per year with direct discharge.

During the flushing of the sediment from the basin, the concentrations of total suspended solids would be monitored and reported to SCDHEC in accordance with the NPDES permit.

4.5.3.6 Atmospheric releases

Nonradiological pollutants emitted into the atmosphere as a direct result of the operation of L-Reactor would come primarily from the K-Area coal-fired steam plant and the diesel generators at the L-Area. The steam demands for L-Reactor would require an additional 6400 metric tons of coal to be burned annually at the K-Area steam plant. Emissions of particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and volatile organic compounds from the steam plant would increase 15 percent, as illustrated in Table 4-7.

Fourteen emergency diesel generators are located in L-Area; six would operate continuously. The estimated annual diesel fuel consumption rate would be 940 cubic meters for all generators. The emissions from these generators are listed in Table 4-7.

The operation of the L-Reactor would not violate any ambient air quality standard.

4.5.3.7 Solid wastes

Solid nonradioactive wastes generated by the resumption of L-Reactor operation would consist of trash and sanitary waste sludge. Trash would be generated at a rate comparable to those experienced by other SRP reactors; it would be disposed of in the SRP sanitary landfill. This landfill will be expanded from about 0.04 to 0.13 square kilometer. This expansion, which will occur in any event, ensures an adequate capacity for SRP operation, including L-Reactor, for many years (Du Pont, 1982b). Ten wells monitor the effluent from the landfill to the ground water of the McBean Formation. Quarterly analyses of water from these wells have shown little impact on the McBean ground water.

Periodically, treated sludge would be pumped from the sanitary waste treatment plant sludge holding tank to a mobile tank and transported to the sludge pit near the Central Shops area. Approximately 48,000 liters (50 percent water) of the sludge from L-Area would be disposed of in the sludge pit annually. No impact is expected on the operation of the sludge pit.

4.5.3.8 Noise

During the normal operation of L-Reactor with the preferred alternatives, any noise external to buildings would be associated primarily with the movement of motor vehicles; it would be undetectable at the nearest offsite residence, about 10 kilometers away.

4.5.4 Radiological impacts of normal L-Reactor operation

4.5.4.1 Atmospheric releases of radioactivity

Table 4-64 lists the atmospheric releases from L-Reactor operation with the reference case system. For the preferred alternatives, tritium, which otherwise would be discharged to Steel Creek from L-Reactor (directly or via a ground-water path from the L-Reactor seepage basin), would be released to the cooling lake. Evaporation and molecular exchange are expected to increase the releases to the atmosphere and thus, decrease liquid releases to the Savannah River. Tritium releases to the atmosphere are expected to increase by about 1 percent on the first year and about 3 percent in the tenth year in relation to those from the reference case, direct discharge.

Table 4-64. Expected annual atmospheric releases from L-Reactor operation^a (curies per year)

Radionuclide	1st-year operation	10th-year operation
H-3 ^b	5,540	56,500
C-14	12	12
Ar-41	19,500	19,500
Kr-85m	600	600
Kr-87	540	540
Kr-88	790	790
I-131	0.00414	0.00414
Xe-133	1,700	1,700
Xe-135	1,400	1,400
Unidentified beta-gamma ^c	0.0002	0.0002
Unidentified alpha ^d	0.000001	0.000001

^aThe expected annual average concentrations at the SRP site boundary would be well within the DOE concentration guides for uncontrolled areas (DOE, 1981b).

^bIncludes evaporative and molecular losses at ground level from the disassembly basin, the seepage basin, and the cooling lake.

^cAssumed to be strontium-90.

^dAssumed to be plutonium-239.

4.5.4.2 Wastewater discharges of radioactivity

Table 4-61 lists wastewater discharges of radioactivity for the reference case. For the preferred alternatives, tritium releases to the Savannah River are less (because the atmospheric releases cover more); they are expected to comprise about 85 percent of the values for the reference case.

4.5.4.3 Cesium-137 and cobalt-60 remobilization

Section 4.1.2.4 describes the estimated cesium-137 and cobalt-60 releases due to the remobilization of these materials in the Steel Creek channel and floodplain. Most of this radioactivity is cesium-137. It is conservatively estimated that the remobilization of cesium-137 and cobalt-60 would be no more than 4.4 ± 2.2 curies and 0.25 ± 0.13 curie, respectively.

4.5.4.4 Offsite dose commitments

The maximum individual and population dose commitments for the preferred alternatives are presented in Table 4-65. These doses are nearly identical to those of L-Reactor operation under the reference case (see Table 4-17). However, the tenth-year population doses within 80-kilometers are slightly higher and the population doses to downstream water users are slightly lower than those in Table 4-17, because of the greater vaporization of tritium from the 1000-acre lake surface.

Table 4-65. Summary of total-body dose commitments from the operation of L-Reactor (preferred alternatives)

Source of exposure	1st-year dose	10th-year dose
MAXIMUM INDIVIDUAL ADULT DOSE (millirem per year)		
Atmospheric release	0.052	0.22
Liquid releases	0.0066	0.072
Radiocesium and cobalt transport	3.5	0.31
Total	3.6	0.60

Source of exposure	Dose within 80 kilometers of SRP		Port Wentworth and Beaufort-Jasper dose	
	1st year	10th year	1st year	10th year
REGIONAL POPULATION DOSE (person-rem per year)				
Atmospheric releases	3.0	13.9	--	--
Liquid releases	0.0087	0.017	0.66	10.8
Radiocesium and cobalt transport	9.0	0.80	0.80	0.067
Total	12.0	14.7	1.5	10.9

4.5.4.5 Health effects

For the preferred alternative, there would be a maximum of 0.001 and 0.002 excess cancer fatality in the population within 80 kilometers of the SRP from the first- and tenth-year operation, respectively, and 0.003 and 0.004 genetic disorder from the first- and tenth-year operation. Similarly, for the downstream Savannah River water-consuming populations at Port Wentworth and Beaufort-Jasper, either alternative is projected to result in a maximum of 0.0004 excess cancer fatality from the first year and 0.002 from the tenth year, and 0.004 genetic disorder from the first year and 0.003 from the tenth year.

A panel of experts, including representatives of the Centers for Disease Control and the South Carolina Department of Health and Environmental Control, is reviewing the results of ongoing health effects and epidemiological studies (see Section 6.1.5). DOE will conduct public hearings on the panel's findings and initiate any required epidemiological study as a result of this process. In addition, DOE will take appropriate mitigative actions on an implementation schedule that is mutually agreed on with the State, if further study indicates such actions are warranted (Memorandum of Understanding of April 27, 1983).

4.5.4.6 Occupational dose

Occupational doses would be the same for the preferred alternatives and the reference case; the doses are expected to be similar to those experienced in the past in P-, K-, and C-Areas, as listed on Table 4-66.

Table 4-66. Total doses to workers
in P-, K-, and C-Areas

Year	Dose (person-rem)
1976	217.2
1977	231.2
1978	202.0
1979	184.4
1980	203.7
Average	207.7
Average per reactor-year	69.2

4.5.4.7 Solid radioactive waste

Low-level solid radioactive waste (about 570 cubic meters annually) would be generated by either the reference case or the preferred alternatives. These wastes would be buried in the SRP low-level waste burial ground. Offsite radiological effects of these operations would be negligible.

4.5.5 Accidents

4.5.5.1 Reactor accidents

The two types of reactor accidents of primary concern at SRP are a release of fission products or other radionuclides from irradiated reactor fuel and targets, and a release of activation tritium from the reactor moderator. The release of fission products is most likely to occur due to fuel or target melting, which might result from either power surges or cooling-system failures.

The release of activation tritium from the reactor heavy water is most likely to occur from spills or pipe breaks.

The principal hazard of these accidents is that the released radionuclides become airborne and are carried either to the onsite plant worker or to the off-site population. Radionuclides can also be dispersed by the reactor liquid effluent streams, but the hazards of such dispersal are several orders of magnitude lower than those of airborne dispersal in an accident situation.

Because the principal hazards are derived from possible airborne releases and because the existing confinement system is both the reference case and the preferred alternative safety system, therefore, the potential effects of reactor accidents will be the same for both cases. To provide a perspective on the overall accident risk of L-Reactor operation, Figure 4-49 shows the annual probability of an individual living at the SRP site boundary receiving more than a certain dose from postulated accidents. Additional details are provided in Section 4.2 and Appendix G.

4.5.5.2 Non-nuclear hazards and natural phenomena

Risks associated with (1) toxic-gas release, (2) fire, (3) earthquakes, (4) tornados and hurricanes, and (5) floods are considered in relation to the reference case (in Section 4.2.2); in all instances the risks are small both in terms of technical assessment and judgment and in terms of experience.

The preferred alternatives include a 1000-acre lake behind an embankment; there would be, therefore, the very small risk of dam failure due to non-nuclear hazards and natural phenomena.

The probability of an embankment failure is extremely low. As indicated in Section L.2.3.2, a conservative approach to earthquake design has been used. Similarly, the embankment, outlet works, and emergency spillway are designed to control the runoff (Section L.2.3.1) from the U.S. Army Corps of Engineers' "standard project flood." At SRP this flood is the result of a 96-hour rainfall of 51 centimeters. The standard project flood does not have a direct correspondence to a recurrence interval. However, 51 centimeters in 96 hours is nearly twice the 100-year recurrence interval depth for the area. Extrapolation of the depth-versus-recurrence-interval relationship for the 96-hour duration at the site would imply a recurrence interval of over 10,000 years. An even rarer flood, the probable maximum flood, was also included in the design basis. The embankment is designed to withstand these events.

The consequence analyses of embankment failure indicate that any loss of life would be unlikely because no SRP facilities or offsite residences exist in the expected path of the resulting flood wave. However, severe economic loss and environmental impacts would occur.

The consequence analyses of embankment failure were based on a reservoir water-surface elevation of 61 meters. This would be the elevation at the top of the embankment, 1.2 meters above the emergency spillway and 1.6 meters above the peak pool level for the standard project flood. Results of the analyses indicate that a failure with the water at the 61-meter elevation would produce a

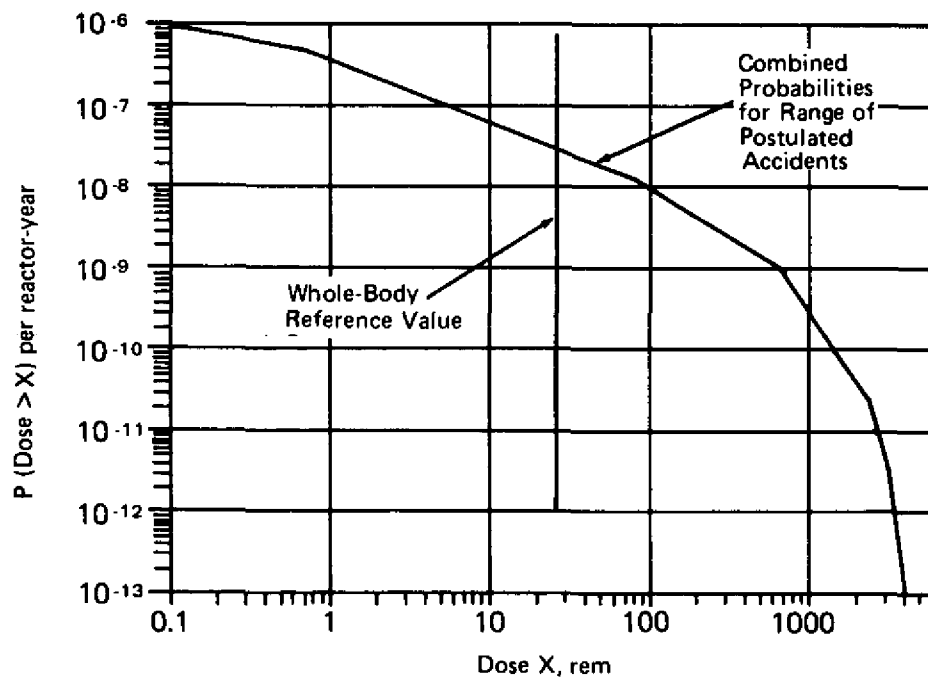
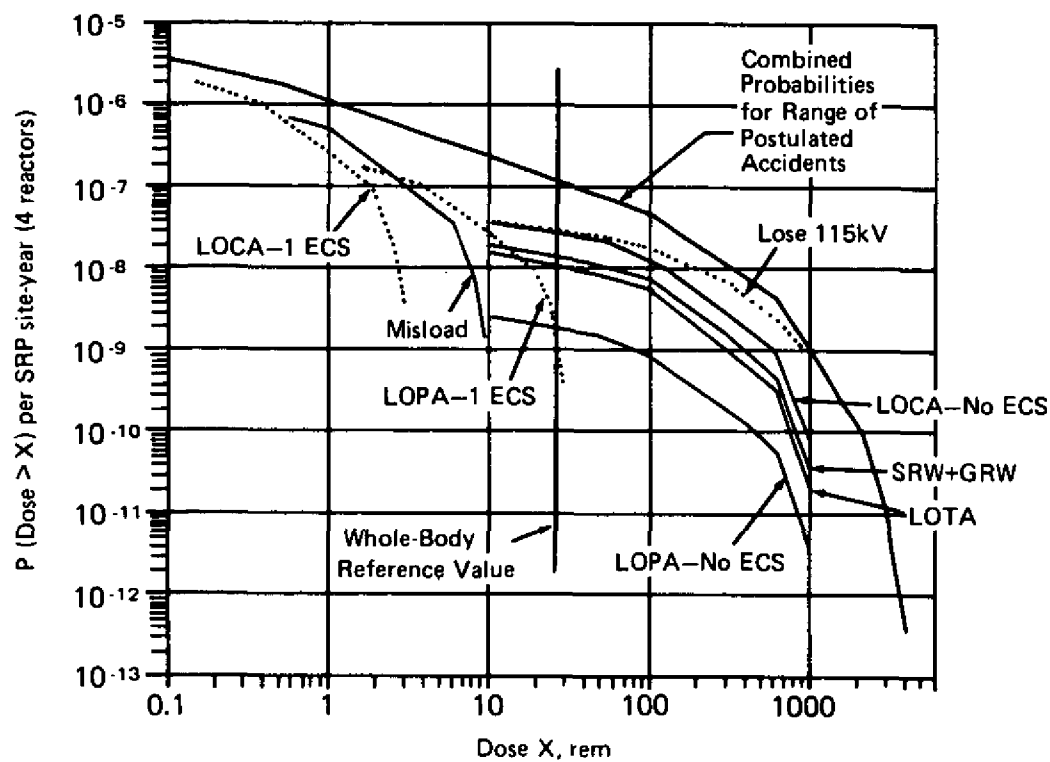


Figure 4-49. Total probability (P) per SRP site-year (upper) and reactor year (lower) that the whole body dose to a person on the plant boundary will exceed a specified value, X rem.

14-meter-high flood wave. The wave height would decrease as it proceeded downstream. At a distance of 3.7 kilometers downstream from the embankment, the wave height would be about half the initial height, or 7 meters. This station is below the Seaboard Coast Line Railroad bridge and the bridge over Road A (SC Highway 125). These bridges would be overtopped and probably destroyed, and their debris would be carried by the flood wave.

At a distance of 5.2 kilometers downstream from the embankment, the wave would have a height of approximately 3.5 meters and be fully into the Savannah River swamp, both on and off the site. This is downstream from the second Seaboard Coast Line Railroad bridge, which is about 900 meters above Cypress Bridge. This railroad bridge would probably be destroyed or severely damaged. The swamp is not deep enough to sustain a wave height of 3.5 meters, and the trees and shrubs would also attenuate the wave. However, as the wave broke and scattered through the swamp, it would uproot trees and vegetation and then deposit the entrained debris, including earth from the embankment, scoured sediment, and bridge debris. The effect on the Savannah River itself is expected to be minor.

4.6 NO-ACTION ALTERNATIVE

This section describes the expected nonradiological and radiological effects due to maintaining L-Reactor in a ready-for-operation standby mode. Non-radiological effects include those that might result from a decreased work force, the periodic withdrawal and discharge of water for hydraulic testing and flushing of the secondary cooling system, the discharge of liquid and atmospheric effluents, and the disposal of solid nonradioactive wastes. Radiological effects include those that might result from the resuspension and transport of radiocesium in Steel Creek as a result of the periodic hydraulic testing and flushing of the secondary cooling system.

Maintaining L-Reactor in a standby mode would have no direct land-use impacts. A work force of only about 100 would be required to maintain L-Reactor, thus necessitating the loss of approximately 300 jobs.

The four historic sites and one prehistoric site in the Steel Creek terrace and floodplain system that are eligible for inclusion in the National Register of Historic Places have shown erosion effects from high-water flow conditions during periodic hydraulic testing and flushing of the secondary cooling system. Phase 2 of the Archeological Mitigation Plan is being implemented to protect these sites. TC

Direct expenditures on materials and services to maintain L-Reactor in a standby mode (\$10-12 million) would be less than the expenditures for operating of L-Reactor. Contributions to the local economy would also be less than those from L-Reactor operation.

The secondary cooling system, a once-through cooling-water system, would be hydraulically tested and flushed approximately 1 day per month; flow rates as high as 6.2 cubic meters per second would be experienced. During hydraulic testing, about 6.2 cubic meters per second of water would be withdrawn from the

Savannah River, about 2 percent of the average river flow and 4 percent of the 7-day, 10-year low flow of 295 and 159 cubic meters per second, respectively. Essentially all of the water withdrawn from the river would be returned to the river after passing through the secondary cooling system and the Steel Creek system.

Based on the results of 1982 and 1983 studies and predicted L-Reactor water withdrawal rates during periodic testing and flushing of the secondary cooling system, fewer than 1.2×10^5 fish eggs and 2.0×10^5 fish larvae would be entrained during the spawning season and an additional 9 fish would be impinged per day of testing and flushing.

TC Two deep wells in L-Area would continue to provide a total of 0.94 cubic meter per minute from the Tuscaloosa Formation; however, there would be no pumping at other facilities in support of L-Reactor. The total drawdown near the center of the cone of depression is estimated to be about 4.3 meters. The upward head differential between the Tuscaloosa and Congaree Formations in L-Area is about 3.7 meters. Thus, near the center of the cone of depression, the head differential would be approximately 0.6 meter downward. The withdrawal of ground water from the Tuscaloosa aquifer in L-Area would not be expected to affect the quality of the ground water.

No liquid thermal effluents would be discharged from L-Area into the Steel Creek system. There would be no thermal impact on the Savannah River; however, during periodic hydraulic testing and flushing of the secondary cooling system, water would be discharged to the Steel Creek system at the ambient river water temperature at approximately 6.1 cubic meters per second. Flooding and minor amounts of siltation associated with the discharge would be expected to temporarily modify the aquatic habitat in the Steel Creek floodplain and delta. These discharges would also temporarily eliminate the feeding habitat for the wood stork and other waterfowl that have been observed in the Steel Creek delta.

The nonthermal liquid effluent from L-Area would have chemical compositions that are similar to those from other SRP reactor areas. Some of the chemicals discharged to Steel Creek would originate from the Savannah River during the periodic hydraulic testing and flushing of the secondary cooling system. Sanitary waste water would be chlorinated at a package treatment plant and discharged through the L-Reactor sewer to Steel Creek. No impacts on the water quality of the swamp or the Savannah River would be expected.

The L-Area cooling-water basin (186-Basin) would be cleaned annually to remove accumulated solids. This sediment would be flushed to Steel Creek over a period of several days, and would settle in the streambed before reaching the swamp. A variance on total suspended solids from the NPDES permit might be required for this activity.

Nonradiological pollutants would be emitted from the K-Area coal-fired steam plant (used to supply L-Area with steam) and the L-Area diesel generators.

Solid nonradioactive wastes would consist of trash and sanitary sewage sludge. Trash would be disposed of in the SRP sanitary landfill, which is operated in accordance with guidelines of the South Carolina Department of Health and Environmental Control. Sewage sludge would be disposed in an existing sludge basin near the Central Shops.

Technological improvements would be incorporated into the L-Reactor concurrently with similar improvements made for the other SRP reactors.

The periodic hydraulic testing and flushing of the secondary cooling system would resuspend and transport only a very small amount of the radiocesium and radiocobalt presently in the Steel Creek system to the Savannah River and the swamp. The resulting maximum individual dose per day of testing/flushing would be approximately 0.003 millirem, the dose per day of testing/flushing to the regional population within 80 kilometers of Savannah River Plant would be 0.008 person-rem, and the dose to the the water consumers in the Port Wentworth, Georgia, and Beaufort-Jasper Counties, South Carolina, areas would be 0.0007 person-rem per day of testing/flushing of the secondary cooling-water system.

4.7 DECONTAMINATION AND DECOMMISSIONING

Whether it is restarted or not, L-Reactor will ultimately be subject to decontamination and decommissioning. The decontamination and decommissioning plan adopted will be subject to environmental and public review before implementation. The options listed below are based on the following studies:

1. NRC Program Status Paper (Calkins, 1980)
2. The decommissioning description for the Defense Waste Processing Facility (DOE, 1981a)
3. The Decommissioning Handbook (Manion and LaGuardia, 1976)
4. The decommissioning plan for the 100-F production reactor at Hanford (DOE, 1979)
5. The shutdown plan used for L-Area in 1968

Three basic decommissioning options are defined according to the NRC Program Status Paper (Calkins, 1980). These options are DECON, SAFSTOR, and ENTOMB. Depending on the results of the later NEPA review, L-Area decommissioning is expected to follow the SAFSTOR option.

DECON is defined as the immediate removal of all radioactive materials to levels that are considered acceptable to permit the property to be released for unrestricted use (NRC, 1981). This option uses a chemical decontamination of the structure and the internals. Decontamination is followed by dismantlement, transportation, and burial of the internals. In a final step, the outer structure is demolished, and the site is restored to its precommissioning status.

ENTOMB is the encasement of the facility in a material possessing long-lived structural integrity until such a time when the dose level is amenable to unrestricted use. This option is intended for sites where the radioactivity will decrease the acceptable limits within a reasonable time period. A reasonable time period for ENTOMB is approximately 100 years (NRC, 1981).

SAFSTOR involves placing a facility in temporary storage within acceptable risk levels for subsequent decontamination and unrestricted facility use. The SAFSTOR option is divided into six major phases:

1. Chemical decontamination
2. Mechanical decontamination and fixing of residual radioactivity
3. Equipment deactivation
4. Preparation for interim care
5. Interim care (surveillance and maintenance)
6. Final dismantlement

Chemical decontamination involves rinsing, chemical cleaning, and flushing of internal surfaces of process lines, vessels, and equipment. External surfaces or process equipment, lines, and structures are sprayed remotely with a series of chemical solutions or steam.

Next, all equipment and systems not needed during this interim-care period are deactivated. Typical activities include final draining of process lines, closing or opening valves depending upon the function, blanking flanges, and disconnecting utilities. Cooling-water systems for diesels are drained and fuel oil is removed from tanks.

During preparation for the interim-care period, security locks are installed on all exterior doors and on doors leading to highly contaminated areas. Intrusion alarms, fire detection systems, radiation monitoring equipment, and ventilation systems are inspected to assure safety during the interim-care period.

During interim care, the facility and the total site are kept inaccessible to the public and unavailable for other than nuclear use. Surveillance, maintenance, certain operations such as ventilation, and security activities are conducted to assure safe confinement of the radioactivity. Scheduled programs of periodic inspections and monitoring are continued.

Final dismantlement begins with a planning phase. The equipment that is necessary for dismantlement but was previously made inoperable is activated and refurbished as necessary. The other phases of final dismantlement are removal of contaminated equipment, mechanical decontamination of structures, demolition of structures, and restoration of the site.

Removal of contaminated equipment involves disconnecting and cutting where necessary for volume reduction; packaging, loading, and transporting the equipment to a waste disposal facility; and final disposal. A remote operational capability is added to accomplish equipment removal where high radiation levels prohibit contact operations.

In the demolition and restoration phase, all above-grade portions of the plant structures are demolished by conventional methods, such as explosive and impact balls. The site is then graded and revegetated.

The impacts from decontamination and decommissioning are very small. Projections of these impacts specific to L-Reactor have not been made; estimates, however, have been made (Marion and LaGuardia, 1976) for the decontamination and decommissioning of commercial power reactors of the PWR design. The estimated

population dose for the DECON option was 3.0×10^{-5} millirem per year (lung) during the period of the decontamination and decommissioning operation. Both the ENTOMB and the SAFSTOR were projected to result in an even lower dose.

The decommissioning of currently operating facilities receiving hazardous and radioactive mixed wastes will be discussed in a separate NEPA review of the "SRP Groundwater Protection Implementation Plan" (see Section F.6).

DA-3

In the case of the preferred cooling-water alternative, the 1000-acre lake would be left intact as a balanced biological community after the decommissioning of L-Reactor.

TC

4.8 SAFEGUARDS AND SECURITY

Safeguards considerations for L-Reactor include physical security and materials control and accountability. The principal requirements are contained in the following DOE orders:

1. DOE Order 5630.1, "Control and Accountability of Nuclear Materials." This order provides guidance in the development of material control and accountability systems for special nuclear material and other designated materials.
2. DOE Order 5630.2, "Control and Accountability of Nuclear Materials, Basic Principles." This order provides specific requirements for the control and accountability of nuclear materials.
3. DOE Order 5632.1, "Physical Protection of Classified Matter." This order prescribes DOE policies and objectives for the physical protection of classified security interests.
4. DOE Order 5632.2, "Physical Protection of Special Nuclear Materials." This order establishes minimum physical protection standards for special nuclear materials.

Access to the site is controlled at primary roads by permanently manned barricades. Other roads are closed to travel by gates or other barriers. The site, except along the Savannah River, is fenced. The entire site is posted against trespass under State of South Carolina and Federal statutes. The operating areas are separately fenced; the fence is continuously patrolled by armed security personnel. Primary responses to safeguards and security incidents are from area patrol personnel who are engaged in roving patrols and/or access control activities. Inter-area security personnel are supplemented by armed responders from other SRP facilities. Responders are equipped with sidearms, shotguns, and automatic weapons. Armored vehicles are assigned to each area and are used in response. Onsite security forces are provided backup by off-duty security personnel and Federal, state, and county law enforcement agencies.

Materials control and accountability procedures are applied to special nuclear materials, such as: enriched uranium, plutonium-239, neptunium, tritium,

and deuterium. Stringent controls are used throughout the manufacturing, storage, and shipment cycles to protect against unauthorized diversions of these materials. Proven measurement and analytical procedures and equipment are used as part of the materials control and accountability system at Savannah River Plant.

L-Area is defined as a material balance area; it is, in turn, divided into material balance sections (e.g., reactor section, disassembly section). Similar material balance areas have been established at the other SRP facilities that will handle the special nuclear materials to support resumed L-Reactor operation. Within each material balance area or section, the accountable materials are kept separate, and identifiable material quantities that enter or leave the area are accurately determined; responsibility for the material is assigned to one individual.

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5 INCREMENTAL AND CUMULATIVE IMPACTS FROM L-REACTOR OPERATION

5.1 INCREMENTAL IMPACTS FROM L-REACTOR SUPPORT FACILITIES

The resumption of L-Reactor operation would increase the number of operating reactors at the Savannah River Plant (SRP) from three to four. It would also increase effluents and emissions from fabrication (M-Area) and chemical processing (F- and H-Areas) support facilities at SRP by about 33 percent. Actual incremental increases might be less, depending on reactor operating schedules and the number of shifts required to support L-Reactor operation. Other SRP facilities that will be affected by L-Reactor operation include the waste management operations and an onsite steam-generating station in K-Area. This section describes the incremental environmental impacts from the SRP support facilities that would result from the resumption of L-Reactor operation under direct discharge of cooling effluent to Steel Creek (the reference case) and the preferred cooling-water alternative described in Section 4.4.2 and in detail in Appendix L.

TC

5.1.1 Nonradiological impacts

The nonradiological impacts from the SRP support facilities associated with the extra support effort due to L-Reactor operation will be fourfold: (1) an increase in the workforce, (2) an increase in water discharges to surface streams and seepage basins, (3) an increase in atmospheric pollutants, and (4) an increase in water usage. These nonradiological impacts are treated individually in Sections 5.1.1.1 through 5.1.1.4.

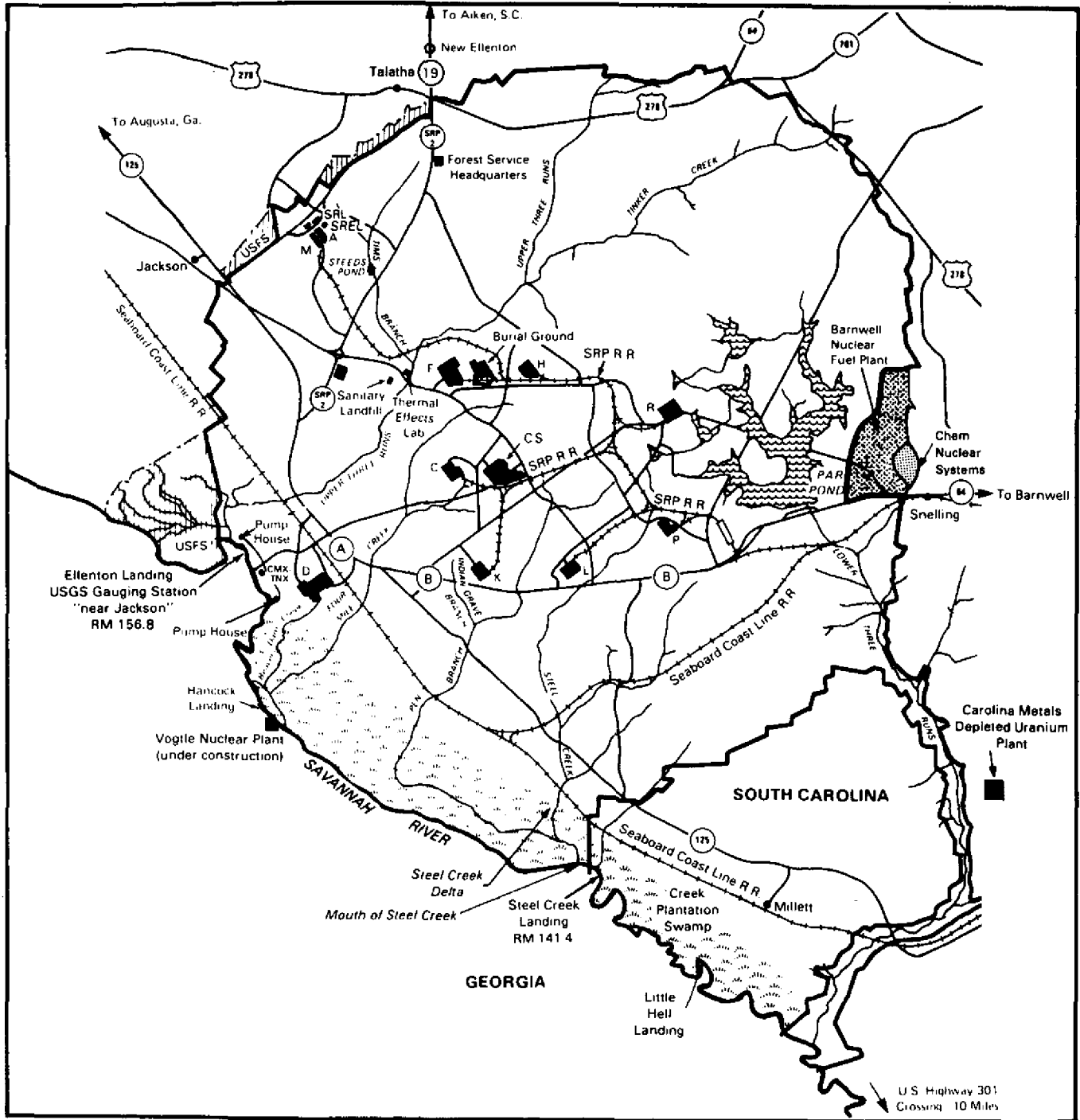
5.1.1.1 Socioeconomics

Approximately 160 employees are expected to be hired by 1984 for existing SRP facilities in support of the resumption of L-Reactor operation. About half have already been hired. Because the number of additional employees to be hired is less than 1 percent of the SRP labor force, and because the inmoving population associated with the potential 80 additional employees is less than 0.05 percent of the indigenous population in the six-county area, no impacts on local communities or services is expected.

5.1.1.2 Effluent discharge

Discharge to seepage basins

Separations Areas--SRP has discharged large volumes of liquids containing nonradioactive chemicals and low levels of radioactivity to the seepage basins in F- and H- (Separations) Areas (Figure 5-1) since 1954 and 1955, respectively. These discharges consist essentially of evaporator condensate from a number of different waste streams, all generated in operations involving radioactive materials. Some of the components in the wastewaters, including mercury,



Legend

- C, K, R, L, P Reactor Areas (C, P, K are operating)
- F, H Separations Areas
- M Fuel and Target Fabrication
- D Heavy Water Production
- A Savannah River Laboratory and Administration Area
- CS Central Shop
- RM River Mile
- Road A = Highway 125

Figure 5-1. Savannah River Plant site.

chromium, and nitrate, have been retained in the seepage-basin soils; some have also entered the shallow ground-water system and are migrating through the saturated soil to outcrop zones, principally to wetland areas near Four Mile Creek (Du Pont, 1983c; Fenimore and Horton, 1972; Horton, 1974; Marter, 1977; Appendix F). In intensive ground-water monitoring studies of nitrate levels conducted in 1968 and 1969 at F- and H-Areas, nitrate concentrations ranged from 3 to 300 milligrams per liter (compared to background concentrations of 3 milligrams per liter in natural ground water).

The present discharges to the F- and H-Area seepage basins are not hazardous (under RCRA) except for frequent periods of low pH and infrequent discharges of hazardous levels of mercury and chromium. The mercury levels are associated with the processing of onsite reactor products and radioactive waste management activities; the chromium levels are associated with the processing of offsite fuels, radioactive waste management, and the removal of oxide from onsite target elements. The incremental increases to the F- and H-Area seepage basins from the operation of L-Reactor are not expected to be hazardous except for low pH and occasional discharges of mercury (H-Area only).

Most of the 435 and 1760 kilograms of mercury released to the F- and H-Area seepage basins, respectively, through 1982 has accumulated in the basin soils. Measurements in 1971 indicated that mercury discharged from seepage springs to Four Mile Creek at a rate of 0.36 gram per day; less than 0.1 percent of the mercury inventory is believed to have migrated to the creek. The ground-water downgradient from these seepage basins shows mercury concentrations 100 times higher than background levels. Recent quarterly monitoring indicates mean concentrations as listed in Table 5-1 (see tabulated monitoring results in Section F.5.3).

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From 1981 through early 1983, about 740 kilograms of chromium were discharged to the H-Area basin. Chromium concentrations in downgradient wells are 1.4 to 2.8 times background levels; in some cases, these exceed drinking-water standards. Large quantities of nitrate and sodium have also been released to these basins. Recent quarterly ground-water monitoring from wells around the F- and H-Area seepage basins indicates mean concentrations of chromium, nitrate, and sodium, as listed in Table 5-1.

The pH of the ground water near the F- and H-Area seepage basins ranges from about 3 to 6 for downgradient wells compared to a range of 5 to 7 for upgradient wells in the area. Appendix F contains additional ground-water monitoring results for the Separations Areas.

The chemical separations of product and waste from the irradiated L-Reactor fuel and target assemblies will result in additional effluent discharges to the seepage basins. During 1982, the average discharge rates were 0.24 and 0.30 cubic meters per minute to F- and H-Area basins, respectively. Because of changes in operating practices, principally by recycling as much as 80 percent of the acid and base drain header flow and rerouting laundry effluent, discharges to the basins in the Separations Areas have been reduced to 0.13 cubic meter per minute to the F-Area basins and 0.28 cubic meter per minute to the H-Area basins. Projected incremental discharges to these basins in support of L-Reactor operation will be approximately 0.04 and 0.09 cubic meter per minute, respectively. The continued use of these seepage basins is being evaluated on a

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Table 5-1. Mean concentrations in F- and H-Area seepage basin monitoring wells (milligrams per liter)

Constituent	Area	Upgradient wells	Downgradient wells ^a	Predicted increase for L-Reactor operation ^b
Mercury	F	0.0002	0.022	0.002
	H	0.0002	0.017	0.001
Chromium	F	0.030	0.041	0.00 ^c
	H	0.018	0.051	0.00 ^c
Nitrite (as nitrogen)	F	2.0	214.0	15.0
	H	1.4	46.0	3.2
Sodium	F	11.3	141.0	10.0
	H	3.6	60.0	4.2

^aAverage quarterly measurements (see Tables F-13 and F-14) in downgradient well showing greatest constituent concentration.

^bThe maximum increase in concentration predicted as the L-Reactor increment is 7 percent; it is stated here in terms of the concentration tabulated for the downgradient well.

^cThe incremental release of chromium from the operation of L-Reactor is calculated to be 0.2 kilogram per year to the H-Area basins only; it is not expected to cause a measurable increase of the concentrations in the conterminous plume.

site-wide basis (see Sections 6.1.6 and F.6). Contingent on Congressional authorization and approval of a FY 1986 funding request, DOE plans to operate an effluent-treatment facility by October 1988 to process the wastewater being discharged to these basins.

Based on past experience, about 8.5 kilograms per year of mercury, about 0.2 kilogram per year of chromium, and larger quantities of other chemicals, listed in Table 5-2, are expected to be discharged to seepage basins in the Separations Areas due to the operation of L-Reactor (ERDA, 1977; Horton and Carothers, 1975).

The reduction of flow rates to the seepage basins is expected to reduce the amount of nitric acid (nitrate ion) released to the basins. In addition, the amount of mercury released to the basins has decreased since the early and mid-1970s. Before 1972, approximately 7.9 and 9.4 kilograms of mercury were released per reactor to the F- and H-Area basins, respectively (Du Pont, 1983c). From the mid-1970s to 1982, the average contribution per reactor has been about 0.7 and 2.1 kilograms, respectively. Incremental releases of mercury from L-Reactor to these basins are expected to be 0.5 and 8.0 kilograms per year, respectively (Table 5-2). The addition of a second evaporator to process radioactive waste in the H-Area waste tanks has caused an increase in the amount of mercury added to the H-Area seepage basins.

Table 5-2. Estimated incremental nonradioactive releases to seepage basins, the separations areas, and the fuel/target fabrication area

Cation/anion	F-Area seepage basins (kg/year)	H-Area seepage basins (kg/year)	M-Area seepage basin (kg/year)
Ammonium	16	8	--
Calcium	110	620	--
Magnesium	50	220	--
Sodium	630	6,880	26,500
Iron	310	190	20
Copper	10	40	3
Aluminum	40	570	9,400
Lead	40	160	0.5
Zinc	100	400	--
Carbonate	0	3,270	--
Chlorine	30	570	260
Nitrite	5	90	50
Nitrate	15,450	34,390	86,400
Sulfate	510	1,530	275
Phosphate	30	4,280	21,700
Chromium	--	0.2	--
Mercury	0.5	8.0	--
Nickel	--	--	8,100
Fluorine	--	--	--
1,1,1 trichloroethane	--	--	6

TC

In 1975 approximately 2310 kilograms of chromium were discharged from the Receiving Basin for Offsite Fuels (RBOF) to the H-Area seepage basins (ERDA, 1977); an additional 120 kilograms were discharged to the F-Area basins. From 1981 through early 1983, the discharge rate to the F-Area seepage basins was essentially zero; it was about 295 kilograms per year to the H-Area basins. The operation of L-Reactor is expected to increase the amount of chromium released to the seepage basins in the Separations Area by only 0.2 kilogram per year. Since mid-1982, newly generated chromium waste from the RBOF facility has been processed through a waste evaporator, which greatly lowers the amount of chromium released to the H-Area seepage basins. Almost all the chromium released to these basins since 1982 has come from processing of radioactive waste produced before 1982. After being processed by the waste evaporator, the concentrated fractions are sent to the high-level radioactive waste storage tanks for processing by the Defense Waste Processing Facility.

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Public health and safety will be assured at F- and H-Areas and at the SRP Burial Ground. Section F.6 describes planned remedial actions. A potential intermediate-term problem exists from the use of these facilities, including the increment in support of L-Reactor operation. Contaminants discharged from the seepage basins and the seepage from the burial ground will flow to seepage springs, principally in wetland areas along Four Mile Creek. The radioactive constituents will meet DOE criteria for releases to uncontrolled areas when Four

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Mile Creek flows into the Savannah River. The direction of ground-water flow and the ground-water islands make it unlikely that any contaminated shallow ground water will reach offsite users. None of the incremental releases from the support of L-Reactor is expected to reach the Congaree Formation. Beneath the central portion of SRP, the flow directions in the Congaree and Tuscaloosa Formations are toward the Savannah River along paths that remain beneath SRP (see Figures F-25 and F-26). These formations discharge to the alluvium in the Savannah River valley. Onsite personnel will be protected by the extensive monitoring program. Monitoring of Congaree and Tuscaloosa wells in the central part of the SRP shows no evidence of contamination (Marine, 1965; Ashley and Zeigler, 1981). Based on water samples obtained (in 1965 and in February 1984) for tritium analysis from the Congaree Formation adjacent to the H-Area seepage basins [well 35-D (Figure F-34)], the green clay has protected the Congaree ground water effectively from contamination that enters the shallow ground-water system from the H-Area basins.

The discharges to the F- and H-Area seepage basins will not affect the heads in the Congaree and Tuscaloosa Formations, and pumping from the Tuscaloosa Aquifer will not affect the heads in the Congaree and overlying formations. The green clay at the base of the McBean Formation will prevent releases to these seepage basins from increasing the head in the Congaree. In addition, the clays in the upper Ellenton Formation and at the base of the Congaree Formation are effective sitewide confining units (see Table F-1); they limit the hydraulic connection between the Tuscaloosa and overlying Congaree Formations. For example, Tuscaloosa cones of depression at A-Area wells are not reflected in water levels in the overlying Tertiary sediments. At F- and H-Areas seepage basins, the changes in water-table elevations are expected to be local and small. Thus, the upward head differential between the Tuscaloosa and the Congaree will not be effected by discharges to the F- and H-Area seepage basins.

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As noted above, the green clay is also an important barrier to the downward migration of contaminants from the seepage basin to lower hydrostratigraphic units. In the Separations Areas, the green clay (about 2 meters thick) supports a head difference of about 24 meters between the McBean and Congaree Formations. Water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin (well 35-D; see Figure F-34) in 1965 (Marine, 1965) and February 1984 indicate that the green clay has effectively protected the Congaree ground water from contamination seeping into the ground in the Separations Area. At the Par Pond pumphouse well (Figure F-13), the green clay also supports a large head difference and the water pumped from the Congaree Formation shows no evidence of tritium contamination, even though tritium concentrations in the pond were measured at 27,000 picocuries per liter. Water pumped from the Congaree by the pumphouse well exhibited tritium concentrations of 170 picocuries per liter or less, compared to concentrations of 260 ± 60 picocuries per liter in offsite well water (Ashley and Zeigler, 1981).

Calculations indicate that incremental nonradioactive releases to seepage basins in the Separations Areas in support of L-Reactor operation will increase the concentrations in the ground-water contaminant plume by about 7 percent. Table 5-1 lists the expected incremental changes calculated for the downgradient monitoring wells exhibiting maximum concentrations of mercury, chromium, nitrate (reported as nitrogen), and sodium. These incremental impacts to the ground water are small.

Contaminants that might enter the shallow ground water from the seepage basins in F- and H-Areas are expected to follow a ground-water path to Four Mile Creek and be discharged along seepage springs to the creek (Du Pont, 1983c; Root, 1983). As a result, concentrations of chloride, nitrate, sulfate, sodium, and calcium are higher in Four Mile Creek upstream from the C-Reactor cooling-water discharge than in Upper Three Runs Creek, but are similar to those in the Savannah River (DOE, 1982a). Tritium and nonvolatile beta activity are also elevated in this stretch of Four Mile Creek (Ashley and Zeigler, 1981); however, they do not exceed DOE concentration guidelines for uncontrolled areas. The expected incremental impacts to the water quality of Four Mile Creek above the C-Reactor outfall due to L-Reactor operation will be small (Table 5-3). The concentrations of pollutants entering Four Mile Creek, when mixed with creek water, are expected to be within drinking-water standards; the water quality of Four Mile Creek below the C-Reactor outfall will remain similar to that of the Savannah River. Tritium and other radionuclides in Four Mile Creek will not exceed DOE concentration guidelines for uncontrolled areas.

Incremental releases caused by L-Reactor operation from the Separations Area seepage basins to Four Mile Creek are expected to have only minor impacts on the ecosystem of the upper reaches of the creek. As listed in Table 5-3, nutrient levels are expected to increase and to result in an increase in the populations of primary producers forming the base of the food web. This will exert some stress on the depauperate fauna found in the creek above the C-Reactor outfall. The depauperate condition of the fauna in this area of the creek might be related to thermal isolation caused by C-Reactor and shading of the overstory (Du Pont, 1981a; McFarlane, 1976).

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The water quality of the Savannah River is expected to meet the criteria for a Class B waterway below Four Mile Creek when the pollutants that enter the river from the F- and H-Area seepage basins are mixed with river water (see Ashley and Zeigler, 1981). The water quality below the SRP is not expected to be adversely affected by SRP effluent discharges (see Table 4-6 and Marter, 1970). Radiological dose commitments from releases seeping from F- and H-Area basins are discussed in Section 5.1.2 and Appendix B. DOE will be conducting studies for the eventual phasing-out of these seepage basins (Section F.6).

In summary, the projected L-Reactor incremental releases to the Separations Areas seepage basins will be 0.04 cubic meter per minute to the F-Area basins and 0.09 cubic meter per minute to the H-Area basins. The chemicals in these releases are expected to increase the concentrations of constituents in the contaminant plume by about 7 percent. The water quality of Four Mile Creek will be degraded as the ground water flows into the creek through seepage springs in low-lying wetland areas. Concentrations of constituents in the creek water will be increased by about 7 percent from F- and H-Area seepage-basin releases to the creek. The average quality of the creek water is expected to be similar to that of the Savannah River above the outfall for C-Reactor, except for pH and nitrate and nitrite solutions.

Fuel and Target Fabrication Area--Waste effluents from production operations in the Fuel and Target Fabrication (M-) Area, shown in Figure 5-1, have been discharged to process sewers since startup in 1952. A seepage basin was put in service in 1958 to settle out and contain uranium discharges from fuel-element production operations. At present very little wastewater seeps from the basin. Instead, most of the water overflows the basin and enters the ground at

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Table 5-3. Water quality of the Savannah River and Four Mile Creek above the C-Reactor outfall, and predicted L-Reactor incremental changes in concentrations in Four Mile Creek resulting from incremental discharges to the Separations Area seepage basins

Parameter	Units	Water quality drinking-water standard ^a	Savannah River 1982 average ^b	Four Mile Creek average ^c		Incremental increase at Four Mile Creek
				1982	1983	
pH	None	6.5 - 8.5 (S)	6.2 - 7.0	6.2 - 7.4	7.2 - 5.8	-0.5
Dissolved oxygen (DO)	mg/liter	>4 (WQS)	9.4	8.8	8.3	NC ^d
Total susp. solids (TSS)	mg/liter	<50 (WQS)	10.0	3.0	4.8	NC
Conductivity	µmohs/cm	--e	+f	+	7.1	10.0
Chemical oxygen demand (COD)	mg/liter	--	+	7.4	8.7	0.6
Ammonia-N	mg/liter	--	0.2	0.003	<0.02	0.004
Chloride (Cl)	mg/liter	<250 (S)	6.1	4.1	3.4	0.4
Alkalinity (CaCO ₃)	mg/liter	--	+	9.5	10.0	1.3
Sulfite/sulfate (S)	mg/liter	<250 (S)	7.6	7.5	6.5	1.0
Nitrite/nitrate (N)	mg/liter	<10 (P)	0.52	2.7	1.8	0.4
Total phosphate (PO ₄)-P	mg/liter	--	0.19	0.02	0.06	0.008

Table 5-3. Water quality of the Savannah River and Four Mile Creek above the C-Reactor outfall, and predicted L-Reactor incremental changes in concentrations in Four Mile Creek resulting from incremental discharges to the Separations Area seepage basins (continued)

Parameter	Units	Water quality drinking-water standard ^a	Savannah River 1982 average ^b	Four Mile Creek average ^c		Incremental increase at Four Mile Creek
				1982	1983	
Calcium (Ca)	mg/liter	--	3.8	2.8	+	0.4
Sodium (Na)	mg/liter	--	10.0	9.5	5.6	1.3
Aluminum (Al)	mg/liter	--	1.3	0.9	0.2	0.1
Total iron (Fe)	mg/liter	<0.3 (S)	0.58	0.38	0.83	0.1
Magnesium (Mg)	mg/liter	--	+	+	0.7	0.1
Manganese (Mn)	mg/liter	<0.05 (S)	+	+	0.14	0.02
Chromium (Cr)	mg/liter	<0.05 (P)	+	+	<0.08	0.01
Zinc (Zn)	mg/liter	<5.0 (S)	+	+	<0.02	0.002

^a(P) = 40 CFR Part 141; (S) = 40 CFR Part 143; (WQS) = Water-quality standards--Federal Register, Part V, Vol. 45, No. 231, 28 November 1980.

^b3.6 kilometers above SRP (Du Pont, 1983c).

^cWater samples obtained at Road A-7, about 5.5 kilometers downstream from the Separations Area.

^dNC = Little or no change expected.

^e-- = No standard.

^f+ = No data.

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Lost Lake (see Figure F-35). The waste effluents have included large volumes of volatile organic compounds used as metal degreasing agents. Some of these solvents have evaporated; however, substantial quantities have seeped into the ground from effluent sewer leaks, the seepage basin, overflow to Lost Lake, and other miscellaneous spill sites. This seepage has entered the shallow ground-water system within the Tertiary Coastal Plain sediments. Ground-water samples taken near the seepage basin have exhibited concentrations of organic degreasers no longer used at SRP as high as 220 milligrams per liter in the water-table aquifer. In the Tuscaloosa Formation, concentrations as high as 27 micrograms per liter have been measured in ground-water samples. However, this contamination appears, on the basis of well surveys and contaminant monitoring results (Section F.5.4), to have resulted from the migration of organic degreasers in the Tertiary sediments down the annuli of wells with defective cement grout between the sediment and the well casings (Geraghty and Miller, 1983; Steele, 1983). Approximately 160,000 kilograms of organic degreasers are believed to have entered the ground in M-Area (more details are provided in Appendix F; Du Pont 1982c, 1983c; Geraghty and Miller, 1983; Steele, 1983). However, the discharge of volatile organic compounds in process wastewaters from M-Area operations has been reduced appreciably by recent changes in operating practices.

Effluent discharged to the M-Area seepage basin frequently meets the definition of hazardous waste because of pH. Typically, the waste stream contains 1,1,1-trichloroethane, but not at levels considered to be hazardous (J. D. Spencer letter to G. A. Smithwick dated May 13, 1983). The pH in the upgradient wells (see Table F-15) ranged from 4.5 to 10.6 during recent quarterly monitoring. At the M-Area seepage basin, there are three distinct pH plumes (Du Pont, 1982c). The pH lobe that appears to originate at the basin and move in the direction of the water-table ground-water flow has a pH range from 9.8 to 11.8. In the ground water beneath the process sewer and the seep area at Lost Lake and between the basin and Lost Lake, the pH ranges between 5.0 and 6.0.

Recent quarterly ground-water monitoring from wells encompassing the M-Area seepage basin and Lost Lake indicate the mean chromium, nitrate, and sodium concentrations listed in Table 5-4.

Currently (February 1984), about 0.48 cubic meter per minute of process and nonprocess effluent is being discharged to the M-Area seepage basin, which overflows to Lost Lake, a nearby Carolina bay. The incremental release associated with L-Reactor is estimated to be 33 percent of the flow rate to the basin (about 0.16 cubic meter per minute at present). Changes in operational practices have reduced the amount of rinse water used in the fabrication of fuel and targets, principally by repiping and rearranging existing rinse tanks and using counter-current and stagnant rinse techniques rather than once-through rinses; these practices are expected to reduce the amount of wastewater discharged to the basin to about 0.05 cubic meter per minute by the end of 1984. The incremental discharge from M-Area that would support the operation of L-Reactor includes approximately 6 kilograms per year of a chlorinated degreasing solvent (1,1,1-trichloroethane) and quantities of other chemicals listed in Table 5-2.

In A- and M-Areas, public health and safety will be protected by the extensive SRP monitoring program and by plume management and remedial action strategies. The sewer line to Tims Branch from M-Area no longer receives process wastewater and the line to the M-Area basin is being repaired. When monitoring first confirmed the presence of chlorinated hydrocarbons in water from A-Area

Table 5-4. Mean concentrations in M-Area seepage basin and Lost Lake monitoring wells (milligrams per liter)

Constituent	Upgradient wells	Downgradient wells ^a	Maximum increase predicted for L-Reactor operation ^b
Chromium	0.016	0.58	0.04
Nitrite (as nitrogen)	2.5	54.7	3.8
Sodium	11.4	86.9	6.1

^aAverage quarterly measurements (see Tables F-13 and F-14) in downgradient well showing greatest constituent concentration.

^bThe maximum increase in concentration predicted as the L-Reactor increment is 8 percent; it is stated here in terms of the concentration tabulated for the downgradient well.

Tuscaloosa wells (Appendix F), the contaminated wells were shut down to protect onsite personnel. Monitoring in A-Area, M-Area, and neighboring municipal water wells has shown that the contaminants have not migrated offsite and that no off-site health risk will exist in the foreseeable future. Contaminants that might reach the Tuscaloosa Formation will be discharged to the alluvium in the Savannah River valley (Section F.2.3.2; Du Pont, 1983c). After they become diluted along the travel path (Figure F-26), these contaminants could be intercepted by some SRP production wells. State and Federal agencies are reviewing plans for impeding the growth of the contaminant plume and the removal of the chlorinated hydrocarbons using recovery wells, and a large air stripper. In addition, the health of onsite personnel will be protected by changes in the water distribution system, which will obtain potable water only from the A-Area Tuscaloosa wells that are unlikely to receive contamination from Tertiary aquifers.

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The high concentrations of chlorinated hydrocarbons found in the A- and M-Area shallow (Tertiary) ground-water system are being removed by both a pilot and a prototype air-stripper unit with capacities of 0.075 and 0.18 cubic meter per day, respectively. These demonstration projects will be phased out as the A- and M-Area ground-water remedial action project (Steele, 1983) is being implemented in August 1984. This project will consist of nine 200-foot-deep interceptor/recovery (I/R) wells and an air stripper with a capacity of 1.5 cubic meters per minute, about three times that of the current discharges to the M-Area seepage basin. It has been designed to prevent chlorinated hydrocarbon contaminants in the shallow ground-water system (within the Tertiary Coastal Plain sediments) from reaching the drinking water of any offsite well or the Tuscaloosa Aquifer. Based on small-scale and prototype systems, the production (I/R) well and air-stripper system is expected to remove about 30 tons of chlorinated hydrocarbons per year for the first few years of operation. Thereafter, the removal rate will decrease as contaminant concentrations decrease. Liquid effluent from the air-stripper column (about 1.1 cubic meters per minute) will

be routed to the A-Area powerhouse process-water system or used as nonprocess cooling water in M-Area. In either case, the wastewater would be discharged through an NPDES-permitted outfall.

Use of the M-Area seepage basin is scheduled to be discontinued by April 1985. At that time, M-Area liquid effluent that would normally be sent to the basin will be processed by a wastewater-treatment plant designed to remove about 650 metric tons per year, including the L-Reactor increment and a 20-percent contingency factor. The plant will be composed of (1) a uranium recovery facility, (2) a facility to remove suspended solids, aluminum, nitrates, phosphates, heavy metals, and oil and grease, and (3) a waste solidification facility to concentrate solutions by evaporation and to mix the concentrate with cement and flyash to form a solid-waste form for storage or disposal.

Process wastewater released to the seepage basin after the restart of L-Reactor (before the operation of the M-Area wastewater-treatment plant) will reach the water table in about 10 to 17 years. These waters will be intercepted by the I/R well system. The cone of depression resulting from pumping by the I/R system will be extensive. For example, the area within the 3-meter drawdown isopleth is expected to have an area of several hundred acres and to extend about 180 meters beyond Lost Lake after 10 years of pumping; below the seepage basin, the expected drawdown is 6 meters. Thus, the remedial-action project will readily intercept, recover, and process L-Reactor (and other) releases to the M-Area seepage basin-Lost Lake system that are discharged before the operation of the wastewater-treatment facility in April 1985.

Incremental pumping from the Tuscaloosa Aquifer in support of L-Reactor will cause an increase in the downward head differential between the Congaree and Tuscaloosa Formations of about 0.75 meter at the M-Area seepage basin. This will tend to increase both the downward migration of contaminants in the ground water and the tendency for migration through the thick, low-permeability lower Congaree and upper Ellenton clay units. After 1 year of pumping by the I/R well system, the expected cone of depression in the Tertiary ground-water system will be nearly coincident with the 100-microgram-per-liter concentration isopleth of the contaminant plume. Appreciable concentrations of contaminants are unlikely to migrate through the clays of the Congaree and Ellenton Formations overlying the Tuscaloosa before the I/R cone of depression reduces the effects of incremental pumping. The I/R cone of depression will grow quickly; it is expected to counter any effect of incremental pumping for L-Reactor. This system is projected to reduce the downward head differential beneath the Lost Lake seepage area by 1.2 meters and 3.6 meters after 1 and 10 years of I/R well operation, respectively.

Nitrate and other contaminants associated with the M-Area process wastewater that reach the water table will be removed by the I/R system and pumped to the air-stripper system during its period of operation (40 years). Chlorinated hydrocarbon concentrations in the feed system to the air stripper are expected to range initially from 38,000 to 115,000 micrograms per liter; nitrate concentrations are estimated to range from a few to about 35 milligrams per liter.

L-Reactor is expected to have a very small impact on the operation of this ground-water remedial project. The incremental seepage from L-Reactor support operations will be not more than 8 percent of the design capacity of the I/R

wells, because the increment of 0.16 cubic meter per minute is expected to decrease to about 0.02 cubic meter per minute by the end of 1984. The small incremental discharges will have only a minor and local effect on water-table contaminant concentrations and elevations beneath the M-Area seepage basin and Lost Lake; the effects will be dissipated during the protracted period of seepage to the water table. The thick, low-permeability clay units of the lower Congaree and upper Ellenton Formations will remain effective confining units for the Tuscaloosa Aquifer; this is shown by the fact that the cone of depression from A-Area withdrawal from the Tuscaloosa Aquifer is not reflected in the water levels in the overlying sediments.

Without the I/R well system, the incremental discharges to the M-Area seepage basin would have only a small impact on concentrations of contaminants in the plume. Calculations indicate that these releases will increase concentrations by about 8 percent. Table 5-2 lists the expected incremental changes calculated for the downgradient monitoring wells that exhibit maximum concentrations of chromium, nitrate (expressed as nitrogen), and sodium.

Small quantities of uranium in the M-Area process wastewater will become associated with the clay materials in the subsurface, such as the green clay (if present), because of uranium's relatively high distribution coefficient (K_d). Ultimately, this material will probably reside in the basal Congaree and upper Ellenton clay units, which are effective confining units throughout the SRP.

In summary, the current project L-Reactor incremental liquid releases to the Fuel and Target Fabrication Area seepage basin are 0.16 cubic meter per minute; by the end of 1984, they will be 0.02 cubic meter per minute. The small incremental discharges will have only a minor and local effect on contaminant levels in the Tertiary ground-water system beneath the seepage areas; the effects will be dissipated during the protracted period of seepage to the water table. The thick, low-permeability clay units of the lower Congaree and upper Ellenton Formations will remain effective confining units for the Tuscaloosa, and incremental releases to the M-Area basin will not contaminate the ground water within this formation.

The A- and M-Area ground-water remedial action project is scheduled to be operating by August 1984. The I/R wells, which will have a capacity of at least 9 times the incremental release, are expected to intercept seepage from the basin and Lost Lake areas when it reaches the water table in about 10 to 17 years. Until the I/R system has been fully operational for about 1 year, the tendency for contaminants in the Tertiary contaminant plume to move downward will be increased as the result of incremental pumping for L-Reactor. Thereafter, the I/R system should counter the effects of incremental pumping. Appreciable concentrations of contaminants are unlikely to migrate through the clays confining the Tuscaloosa from L-Reactor restart until the I/R system has been pumping for 1 year. Use of the M-Area seepage basin is scheduled to be discontinued by April 1985, when a wastewater-treatment facility will be in service.

Ash basin

Additional discharges of coal ash will be sluiced (mixed with water and discharged) to the K-Area ash basin for disposal as a result of the production of steam for L-Reactor operation. The additional burning of coal with an ash

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content of about 13 percent will produce approximately 815 metric tons of ash per year. Incrementally, this ash will increase the K-Area steam-plant discharge to the ash basin by about 15 percent. A proposed project would adjust the pH of the sluicing water so the water is within discharge limits (SCDHEC, 1979). Leachate from the ash basin will enter the shallow ground-water system of the Barnwell Formation, from which it will migrate to Pen Branch. Little impact is anticipated.

Effluent treatment processes

Alternatives to the discharge of process wastewaters to the seepage basins in the fuel and target fabrication and chemical separations areas are being investigated, with the intent that these basins will be closed and that decommissioning activities will begin in 1985 and 1988, respectively.

DA-7 | In the fuel and target fabrication area, an integrated system is being designed for the treatment of all M-Area process effluents except clean (non-contact) cooling water. This facility, which is scheduled for operation by April 1985, will utilize precipitation, evaporation, cation exchange, electro-dialysis, and water purification (rinsing) techniques to remove chemicals from the wastewater and allow discharge to Tims Branch through an NPDES-permitted outfall.

DA-7 | For the Separations Areas seepage basins, a waste-treatment facility is being developed to remove radioactive isotopes, hazardous heavy metals, and other dissolved and undissolved solids; direct discharge to Four Mile Creek will be used, through an NPDES-permitted outfall. Unit operations of filtration, reverse osmosis, and ion exchange will be utilized to clean up the process effluent. Operation of this facility is scheduled for October 1988. DOE will submit a FY 1986 funding request to Congress for approval.

Releases to surface streams

The operation of L-Reactor will cause an incremental increase of about one-third in the direct discharge of liquid effluent from the separations areas to surface streams. As listed in Table 5-5, F-Area will discharge an additional 890 liters per minute to Four Mile Creek; the increment to Four Mile Creek from H-Area will be about 1040 liters per minute (Du Pont, 1982b). Table 5-5 also lists the expected concentrations of pollutants in the liquid effluents to these streams and compares the concentrations to applicable drinking-water standards or water-quality criteria.

In general, at the outfall these releases already meet the State of South Carolina release requirements for Class B streams (SCDHEC, 1981). However, the pH of these discharges will occasionally exceed standards and require treatment.

5.1.1.3 Atmospheric releases

Incremental impacts of nonradiological atmospheric pollutants will occur because of the increased steam, electricity, and other processes that L-Reactor operations will require. However, these are not expected to cause any violations of regulations or air-quality standards.

Table 5-5. Expected incremental effluent concentrations from chemical separations areas (F and H) to surface streams^a

Constituent	F-Area cooling water/process sewer outfall to Four Mile Creek ^b	H-Area cooling water/process sewer outfall to Four Mile Creek ^b	H-Area mfg. bldg. outfall to Four Mile Creek ^b	1982 Mean concentrations in Four Mile Creek at Road A-7	Drinking water standards or water quality criteria ^c
Incremental increase in effluent discharged (liters/min)	890	650	390	-	-
pH	5.3-6.9	5.9-6.8	2.9-7.8	6.2-7.4	6.5-8.5 (S)
BOD	<2	<2	2	-	-
Total suspended solids (TSS)	10	32	6	3	-
Oil and grease	<10	<10	<10	-	-
Lead (Pb)	<0.001	0.004	0.006	<0.5	0.05 (P)
Mercury (Hg)	<0.0002	0.0011	0.0007	-	0.002 (P)
Nickel (Ni)	0.006	0.014	0.02	-	0.013 (WQS)
Silver (Ag)	<0.001	<0.0003	<0.0003	-	0.05 (P)
Zinc (Zn)	0.034	0.063	0.084	-	5 (S)
Chloride (Cl)	<0.1	Nb ^d	6.6	4.1	250 (S)
Fluoride (F)	<0.1	<0.1	<0.1	-	1.4-2.4 (S)
Nitrite/nitrate-N(NO ₂ /NO ₃)	0.35	<0.05	0.19	2.71	10 (P)
Phosphate-P(PO ₄)	0.05	0.02	0.01	<0.02	-
Cyanide (CN)	<0.02	<0.02	<0.02	-	0.02 (WQS)
Phenols	<0.002	<0.002	<0.002	-	3.5 (WQS)
Copper (Cu)	- ^e	-	-	-	1 (S)
Iron (Fe)	-	-	-	0.38	0.3 (S)
Manganese (Mn)	-	-	-	-	0.05 (S)
Aluminum (Al)	-	-	-	<0.85	-

^aAll concentrations are mg/liter unless otherwise noted.^bDu Pont, 1982b.^cDrinking water standards: (P), 40 CFR Part 141; (S): 40 CFR Part 143; water quality criteria (WQS): Federal Register, Part V, Vol. 45, No. 231, Nov. 28, 1980.^dNot detectable.^eData not available.

L-Reactor production will increase the amount of fuel and target material processing in F-, H-, and M-Areas. The main environmental impact of increased operations in these facilities will be the added release of NO_x to the atmosphere.

Projected 1985 NO_x releases from F-Area will rise at least two-fold due to both L-Reactor restart and other SRP program changes. NO_x emissions from H-Area will decrease by a factor of two. About 25 percent of the total F-, H-, and M-Area emissions in 1985 will result from processing L-Reactor materials (Table 5-6). Air emissions permits for these facilities have been revised to reflect process changes.

Table 5-6. Summary of air pollutant releases from L-Reactor support facilities

Area	Projected 1984-1985 emission tons/yr		
	SO _x	TSP	NO _x
K-Area coal	130	28	45
L-Area diesels	4	4	59
F	<1	<1	197
H	<1	<1	28
M	<1	<1	26
Total SRP ^a	10,000	2500	5500

^aBased on adjusted values in ERDA (1977).

NO_x releases resulting from L-Reactor operations are higher than other air pollutant emissions increases (Table 5-6). Overall, L-Reactor restart will increase future SRP NO_x emissions by about 5 percent. Sulfur dioxide and total suspended particulate releases will add about 1 percent. Releases related to L-Reactor operation will contribute 1.1 micrograms per cubic meter NO_x to the ambient air at the SRP boundary. This compares to 15 to 23 micrograms per cubic meter NO_x estimated from all other SRP sources in 1985. Total sulfur dioxide and total suspended particulate releases from L-Reactor restart will add less than 1 gram per cubic meter each.

5.1.1.4 Water usage

Surface water

Only minor amounts of surface water will be used by SRP facilities to support L-Reactor operation, because ground water will be the principal source of process water at these facilities. It is estimated that the K-Reactor steam plant will require about 0.005 cubic meter per second additional water from the

Savannah River to produce steam for L-Reactor (Du Pont, 1981b). Sections 4.1 and 4.4.2 describe surface-water use for L-Reactor; Section 5.2 describes cumulative surface-water use.

Ground water

Incremental ground-water pumping from the Tuscaloosa Formation, required to support the resumption of L-Reactor operation, will occur in five areas on the SRP: K-Area (steam plant), the central shops, and F-, H-, and M-Areas (Table 5-7). The incremental drawdowns listed in Table 5-6 represent the best estimates based on the recommended drawdown curve (Siple, 1967; Section F.4.2). At F-Area, the incremental pumping will be about 1.13 cubic meters per minute. After the F-Area powerhouse is placed in standby status in September 1984, the total ground-water withdrawal from the Tuscaloosa in F-Area will be about 4.54 cubic meters per minute, including the increment for L-Reactor. No incremental pumping in support of L-Reactor is expected at H-, A-, and M-Areas, where water conservation and other operational procedures have been instituted. However, if L-Reactor does not restart, ground-water withdrawal at these facilities might decrease by as much as 25 percent. Ground-water withdrawal by A-Area wells could be reduced by 1.1 cubic meters per minute when the wastewater from the M-Area air stripper is used in the A-Area powerhouse to augment the process water flow (Steele, 1983); this potential reduction is not considered in this EIS.

The incremental withdrawal of water from the Tuscaloosa Formation at K-Area will not affect the protection of the Ellenton and Tuscaloosa aquifers afforded by the upward head differential between the Tuscaloosa and Congaree Formations. In the Central Shops and F-Area, this head differential no longer exists at the producing wells, and the downward head differential at these wells will be increased when the incremental pumping for L-Reactor starts. Increased pumping at H-Area has also caused a downward head differential at H-Area wells. However, the hydrostratigraphic properties of the overlying units will continue to offer protection to the Ellenton and Tuscaloosa aquifers at the pumping wells. At the seepage basins the upward head differential between the Tuscaloosa and Congaree Formations will be gradually reduced by drawdown to about 3.7 meters in F-Area. In H-Area the head differential will become about 0.6 meter downward. The head differential in the Central Shops Area will also become downward (Table 5-7).

In A- and M-Areas the hydrostratigraphic characteristics of the subsurface materials are different from those in F- and H-Areas (Table F-1). In addition, the downward head differential between the Congaree and Tuscaloosa Formations will be increased by about 0.75 meter at the M-Area seepage basin as the result of increased pumping to support L-Reactor. This could increase the tendency for contaminants already present in the ground water to move downward. As noted in Appendix F, the ground-water aquifers beneath M-Area have received contaminants contained in M-Area effluents. Current plans call for (1) establishing a series of additional interceptor/recovery wells by August 1984 (Steele, 1983) to remove these contaminants before they migrate offsite or into the Tuscaloosa Aquifer, and (2) discontinuing the use of the M-Area settling basin by April 1985. An extensive monitoring and cleanup program has been initiated. Contaminants that might reach the Tuscaloosa Formation eventually would be discharged to alluvium in the Savannah River valley. After dilution and radioactive decay had occurred along the travel path, these contaminants could be intercepted by some SRP production wells.

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Table 5-7. Estimated L-Reactor support incremental ground-water usage and effects^a

Location	No. wells	1982	1983		Estimated L-Reactor increment		Estimated totals			Comments
		Upward head differential at basin (m)	Use (m ³ /min)	Draw-down ^b (m)	Use (m ³ /min)	Draw-down ^b (m)	Use (m ³ /min)	Well ^b (m)	Basin (m)	
K-Area (steam-plant)	2	7.6	1.13	3-5	0.14	≤0.5	1.27	≤6	1.8	An upward head differential ^c will exist at wells. This and the hydrostratigraphic properties of the formations will tend to protect the Ellenton and Tuscaloosa Formations from contaminants seeping from overlying shallow groundwater units. K-Area seepage, coal, and ash-basin effluents reaching the shallow ground water will be diverted to outcrops along Pen Branch.
Central Shops ^d	3	2.4	0.57	3-4	0.17	≤0.6	0.74	≤5	2.7	A downward head differential will exist at wells and beneath basins. The hydrostratigraphic properties of the formations will tend to protect the Ellenton and Tuscaloosa Formations from contaminants seeping from overlying shallow ground-water units.
F-Separations Area	6	7.6	3.41 ^e	≤6.5	1.13	1.1	6.17	≤8	3.9	No upward head differential will be present at wells, but an upward differential will be present beneath the seepage basins. The hydrostratigraphic properties of the formations will tend to protect the Ellenton and Tuscaloosa Formations from contaminants seeping from overlying shallow ground-water units. Seepage, coal and ash-basin effluents will be diverted to outcrops along Four Mile Creek.
H-Separations Area	5	3.0	7.19	≤9	1.80	0.90	7.19	≤9	3.6	No upward head differential is present at wells or seepage basins. The hydrostratigraphic properties of the formations will tend to protect the Ellenton and Tuscaloosa formations from contaminants seeping from overlying shallow ground-water units. Seepage, coal and ash-basin effluents will be diverted to outcrops along Four Mile Creek.

Table 5-7. Estimated L-Reactor support incremental ground-water usage and effects^a (continued)

Location	No. wells	1982	1983	Estimated L-Reactor increment		Estimated totals			Comments
		Upward head differential at basin (m)	Use (m ³ /min)	Draw-down ^b (m)	Use (m ³ /min)	Draw-down ^b (m)	Use (m ³ /min)	Drawdown at Well Basin (m) ^c	
M-Fuel/Target Fabrications Area ^g	4	-5.5	6.81	<8	1.70	0.75	6.81	<8 3.0	A downward head differential exists in the neighborhood of A- and M-Areas, and important clay layers are absent in this locality. The Ellenton and Tuscaloosa Formations have received contaminants contained in M-Area effluents via wells with faulty construction. Pumping from A-Area wells (which supply M-Area) has the potential for increasing contamination of these aquifers. No offsite contamination has occurred and none is likely to occur in the foreseeable future. Under present plans, use of the M-Area settling basin will be discontinued in 1985.

Total L-Reactor increment = 4.94 m³/min

^a1983 conditions and incremental effects based on information presented in Appendix F and Siple (1967).

^bEstimated drawdown near the center of cone of depression of pumping well, including effects from other pumping areas and neglecting well entrance losses.

^cUpward head differential between the Tuscaloosa (higher pressure) and Congaree (lower pressure) Formations in meters of water.

^dGround-water usage based on Table F-10 in Appendix F; incremental usage take as 1/3 current usage.

^eUsage in 1984 after F-Area powerhouse is placed in standby status.

^fGround-water usage is not expected to increase to accommodate L-Reactor; however, if L-Reactor does not restart, ground-water withdrawal rates might decrease as much as 25 percent.

^gGround-water usage is not expected to increase to accommodate L-Reactor, because fuel and target assemblies are being manufactured in M-Area that could be used in L-Reactor. The well field producing water for M-Area is in A-Area (see Figure F-37). If L-Reactor does not restart, withdrawal rates might decrease by as much as 25 percent.

Ground-water flow in the Tertiary ground-water system below M-Area is also away from the nearest site boundary and toward the Savannah River (Section F.2.3.2 and Figure F-26; Du Pont, 1982). More recent water-level measurements indicate that the flow direction in the M-Area Tertiary ground-water system is to the south in the lower part of the system; the dominant flow direction in the overlying water-table aquifer is to the west-southwest.

The 1985 projected ground-water consumption from the Tuscaloosa at SRP, including that in support of L-Reactor [0.94 at L-Area + 4.94 total incremental (Table 5-7) = 5.9 cubic meters per minute], is estimated to be 25.4 cubic meters per minute. This represents a 7-percent increase over the 1982 SRP withdrawal from the Tuscaloosa of 23.8 cubic meters per minute, but a 6-percent decrease from the 1983 withdrawal rate of 27.0 cubic meters per minute (Tables 5-7 and F-10).

Computer modeling by Marine and Routt (1975) indicated that the ground-water flux in the aquifer is about 110 cubic meters per minute throughout a study area that includes SRP and nearby users (Figures F-25 and F-31). The current ground-water flux through this study area is estimated conservatively to be 51 cubic meters per minute, which is the lower bound estimate. This flux estimate compares with the projected withdrawal rate of about 36.9 cubic meters per minute (11.5 for neighboring offsite users + 25.4 projected SRP usage, including L-Area and support facility incremental use; see Section 5.2.3 for a discussion of cumulative ground-water withdrawal). The SRP projected pumpage rate of 25.4 cubic meters per minute compares with 37.8 cubic meters per minute, which Siple (1967) concluded could be pumped at the SRP with no adverse effects on the pumping capabilities of existing 1960 wells, particularly additional wells if spaced to minimize interference between wells. In 1960, SRP pumpage from the Tuscaloosa was about 18.9 cubic meters per minute (Siple, 1967).

Calculations were performed to evaluate the relationship between ground-water withdrawal and water levels in the Tuscaloosa Aquifer (see Section F.4.2). They showed that water levels in municipal wells near SRP would decrease slightly (0.0 to 0.4 meter) from the 1982 level when pumping at SRP increases (after September 1984) to 25.4 cubic meters per minute (which includes pumping at L-Area and incremental pumping in support of L-Reactor operations). Table 5-8 lists the declines calculated for wells near SRP. These drawdowns reflect rapid (about 100 days; Mayer et al., 1973) adjustments in equilibrium levels rather than aquifer depletion. These declines, calculated for municipalities and other users that would probably experience the greatest impacts from pumping at SRP, are less than half the increase in water levels experienced in Tuscaloosa wells in 1973 in response to an appreciable increase in water precipitation (see Figure 3-11). Long-term cyclic changes of 2 meters have been observed in water levels of the Tuscaloosa Aquifer in wells near SRP (see Figure F-12). In addition, drawdown calculations showed that the declines in water levels at monitoring wells P7A, P54, and P3A since 1974 were related primarily to increased ground-water withdrawal at SRP. Because pumpage will be relatively stable over the next 6 years (see Section 5.2.3), the 0.16-meter-per-year decrease reflected in monitoring well P7A (Figure 3-11) is expected to be arrested (equilibrium water levels are not expected to change appreciably).

The withdrawal of ground water from the Tuscaloosa Aquifer in support of L-Reactor operation is not expected to affect the quality of water.

Table 5-8. Decline in Tuscaloosa Aquifer water levels due to pumping at all SRP facilities^{a,b,c}

Offsite Location	Equilibrium declines in water levels from 1982 levels (meters)	
	Incremental pumping (25.4 m ³ /min)	Cumulative pumping (26.5 m ³ /min)
Beach Island	<<0.1	<<0.1
New Ellenton	<0.1	<0.1
Talatha	0.1	0.1
Jackson	0.4	0.4
SRP boundary opposite A-Area	0.4	0.4
Willinston	<<0.1	<<0.1
Barnwell NFP	<0.1	<0.1

^aComparison made to conditions in May and June 1982 using average withdrawal rates at SRP for 1982 (23.8 cubic meters per minute).

^bCalculations were made using the leaky aquifer model (Siple, 1967) discussed in Section F.4.2.

^cThese drawdowns from incremental and cumulative pumping will occur rapidly; near-equilibrium levels are expected in about 100 days. They have about the same magnitude as changes in water levels in response to short-term changes in winter precipitation (Figure 3-11). Long-term cyclic changes in Tuscaloosa Aquifer water levels of 2 meters have been observed in wells in the SRP area (Figure F-12).

In conclusion, the incremental ground-water withdrawal from the Tuscaloosa Aquifer in support of L-Reactor operation (about 4.94 cubic meters per minute) is expected to have little (less than 0.4 meter) impact on offsite water levels. Beneath the Central Shops and H-Area basins, the head differential between the Tuscaloosa and Congaree is expected to become downward; the differential in A- and M-Areas is expected to become increasingly downward. However, the green clay has a very low permeability and appears to be an effective barrier to the downward migration of pollutants wherever it is present on SRP. The lower Congaree and upper Ellenton clay units act as similar barriers for the Tuscaloosa Aquifer.

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5.1.2 Radiological effects of support facilities

The resumption of L-Reactor operation will result in an increase of about 33 percent in radioactive discharges from the support facilities (i.e., central shops area, heavy-water area, fuel fabrication area, and the separations areas). Releases from support facilities associated with L-Reactor operation will build up gradually; during the first year of L-Reactor operation they will be less than 50 percent of the equilibrium values in succeeding years. However, for the purpose of the present analysis, it is assumed that first-year releases are equal to the expected equilibrium annual average releases. This section characterizes the radioactive releases from support facilities and presents the radiological impact of the releases on the maximally exposed individual and on population groups. Appendix B contains the methodology of the calculations and detailed dose results, including tables that provide the doses by age groups, organs, and pathways.

5.1.2.1 Liquid releases

Liquid radioactive releases will increase from the chemical separations areas, the fuel fabrication area, the heavy-water rework area, and the central shops area as a result of the resumption of L-Reactor operation. Tables 5-9, 5-10, and 5-11 list the expected annual average incremental increases in liquid releases from support facilities to surface streams, to seepage basins, and to surface water from the seepage basins, respectively. The values listed for the releases from these areas to surface streams and seepage basins are based on the average releases from the areas for 1978, 1979, and 1980, which were associated with the operation of three reactors. Since the mid-1950s, SRP has discharged large volumes of liquids containing low levels of radioactivity to the F-, H-, and M-Area seepage basins. The seepage basin soils have retained some of the components in the process wastewaters; others have entered the shallow groundwater system and are migrating to outcrop zones along Four Mile Creek (Fenimore and Horton, 1972; Marter, 1977). The migration of L-Reactor-related radioactivity from seepage basins to surface streams will occur approximately 4 years after initial discharge to the basins.

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5.1.2.2 Atmospheric releases

The restart and operation of L-Reactor will increase the release of radionuclides to the atmosphere from the chemical separation areas, the fuel fabrication area, and the heavy-water rework area. Table 5-12 lists the annual average incremental increase in releases of radioactivity to the atmosphere from L-Reactor support facilities. These incremental releases are based on the annual average release for these facilities for three reactor operations for 1978, 1979, and 1980.

Table 5-9. Estimated incremental releases of radionuclides to surface streams due to operation of L-Reactor support facilities (curies per year)

Radionuclide	Separations areas (F&H)	Fuel fabrication area (M)	Heavy-water rework area (D)	Total
H-3	3.9×10^1	--	5.2×10^2	5.6×10^2
Sr-89, 90 ^a	5.8×10^{-2}	--	3.5×10^{-3}	6.2×10^{-2}
Cs-134, 137	1.9×10^{-2}	--	8.0×10^{-5}	1.9×10^{-2}
U-235	--	5.0×10^{-2}	--	5.0×10^{-2}
Pu-239 ^a	2.9×10^{-3}	--	7.0×10^{-6}	2.9×10^{-3}

^aUnidentified beta-gamma releases are assumed to be Sr-90; unidentified alpha releases are assumed to be Pu-239.

Table 5-10. Incremental radionuclide releases to seepage basins from support facilities^a (curies per year)

Isotope	Separations area (F&H)	Fuel fabrication area (M)	Central shop (CS)	Total
H-3b	5.7×10^3	--	2.0×10^{-1}	5.7×10^3
Cr-51	3.6×10^{-1}	--	--	3.6×10^{-1}
Co-58, 60	5.4×10^{-2}	--	3.0×10^{-6}	5.4×10^{-2}
Zn-65	3.0×10^{-2}	--	--	3.0×10^{-2}
Sr-89, 90	5.9×10^{-1}	--	1.0×10^{-6}	5.9×10^{-1}
Nb-95	8.2×10^{-1}	--	--	8.2×10^{-1}
Zr-95	1.3	--	--	1.3
Ru-103, 106	9.9	--	--	9.9
Sb-124, 125	1.1×10^{-2}	--	--	1.1×10^{-2}
I-131	1.3×10^{-2}	--	--	1.3×10^{-2}
Cs-134, 137	2.4	--	1.0×10^{-6}	2.4
Ce-141, 144	3.0	--	--	3.0
Pm-147	1.2×10^{-1}	--	--	1.2×10^{-1}
Am-241, 243	3.3×10^{-2}	--	--	3.3×10^{-2}
Cm-242, 244	1.0×10^{-3}	--	--	1.0×10^{-3}
U-235, 238	7.3×10^{-2}	3.5×10^{-2}	--	1.1×10^{-1}
Pu-238, 239	2.2×10^{-2}	--	--	2.2×10^{-2}
Other beta, gamma ^c	9.3×10^{-2}	--	5.0×10^{-6}	9.3×10^{-2}
Other alpha ^c	--	--	3.0×10^{-7}	3.0×10^{-7}

^aAdapted from Du Pont (1982a).

^bThirty percent of tritium is assumed to evaporate and be released to the atmosphere at ground level.

^cFor calculational purposes, unidentified beta-gamma releases were assumed to be Sr-90; unidentified alpha releases were assumed to be Pu-239.

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Table 5-11. Estimated incremental releases of radionuclides to streams from seepage basins due to operation of support facilities (curies per year)

Radionuclide	Central shops area ^a	Fuel fabrication area ^b (M)	Separations areas ^c (F&H)	Total
H-3	1.7×10^{-1}	--- ^d	3.2×10^3	3.2×10^3
Co-60	1.9×10^{-6}	---	3.3×10^{-2}	3.3×10^{-2}
Zn-65	---	---	5.8×10^{-4}	5.8×10^{-4}
Ru-106	---	---	6.9×10^{-1}	6.9×10^{-1}
Sb-125	---	---	4.2×10^{-3}	4.2×10^{-3}
Ce-144	---	---	1.0×10^{-1}	1.0×10^{-1}
Pm-147	---	---	4.4×10^{-2}	4.4×10^{-2}

^aConservatively estimated travel time to outcrop equals 3.3 years.

^bOnly uranium isotopes will be released to this basin (see Table 5-10).

Due to their adsorption on soils, they will not be discharged from the ground water during L-Reactor operation.

^cTravel times to outcrop from F- and H-Areas are 6.7 and 1.1 to 3.8 years, respectively. For calculational purposes, the travel time was assumed to be 3.8 years from both areas.

^dNot detectable.

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5.1.2.3 Dose commitments from L-Reactor support facilities operations

Maximum individual dose from liquid releases

The total-body dose to the maximally exposed individual from liquid effluents from the operation of the L-Reactor support facilities was calculated to be 0.022 millirem to an adult in the first year of operation and 0.050 millirem in the tenth year (after seepage-basin contributions start). The maximum organ dose was calculated to be 0.18 millirem to a child's bone in both the first and tenth years.

Population dose from liquid releases

The total-body dose due to liquid releases from L-Reactor support facilities to the population within 80 kilometers of the Savannah River Plant was calculated to be 0.044 person-rem in the first year and 0.048 person-rem in the tenth year. The bone dose was 0.25 person-rem in both the first and tenth

Table 5-12. Estimated incremental annual average releases of radio-nuclides to the atmosphere from operation of L-Reactor support facilities^a (curies per year)

Radioisotope	Separations areas (F&H)	Fuel-fabrication area (M)	Heavy-water area (D)	Total
NOBLE GASES				
Kr-85	2.0×10^5	--- ^b	---	2.0×10^5
Xe-131m	1.9	---	---	1.9
Xe-133	1.0×10^{-1}	---	---	1.0×10^{-1}
OTHER AIRBORNE				
H-3	8.6×10^3	---	7.9×10^2	9.4×10^3
C-14	8.0	---	---	8.0
Sr-90 ^c	1.7×10^{-3}	---	---	1.7×10^{-3}
Zr-95	6.0×10^{-3}	---	---	6.0×10^{-3}
Nb-95	1.2×10^{-2}	---	---	1.2×10^{-2}
Ru-103	1.2×10^{-3}	---	---	1.2×10^{-3}
Ru-106	2.8×10^{-2}	---	---	2.8×10^{-2}
I-129	7.0×10^{-2}	---	---	7.0×10^{-2}
I-131	1.7×10^{-2}	---	---	1.7×10^{-2}
Cs-134	1.1×10^{-4}	---	---	1.1×10^{-4}
Cs-137	1.2×10^{-3}	---	---	1.2×10^{-3}
Ce-141	8.0×10^{-5}	---	---	8.0×10^{-5}
Ce-144	8.0×10^{-3}	---	---	8.0×10^{-3}
U-235	1.7×10^{-3}	---	---	1.7×10^{-3}
U-238	---	8.6×10^{-7}	---	8.6×10^{-7}
Pu-238	1.9×10^{-3}	---	---	1.9×10^{-3}
Pu-239 ^c	2.7×10^{-4}	2.6×10^{-6}	---	2.7×10^{-4}
Am-241	3.9×10^{-4}	---	---	3.9×10^{-4}
Cm-244	3.5×10^{-4}	---	---	3.5×10^{-4}

^aAdapted from Du Pont (1982a).

^bNot detectable.

^cUnidentified beta, gamma releases are assumed to be Sr-90; unidentified alpha releases are assumed to be Pu-239.

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years. The corresponding incremental total-body dose to the populations consuming river water at the Port Wentworth and Beaufort-Jasper water treatment plants was calculated to be 0.95 person-rem in the first year and 5.3 person-rem in the tenth year. The bone dose was 7.9 person-rem in both the first and tenth years.

Maximum individual dose from atmospheric releases

The individual who would receive the highest dose from atmospheric releases from L-Reactor support facilities was assumed to reside continuously on the SRP boundary. The location on the site boundary where this individual resides was selected as the one where the total maximum offsite doses from L-Reactor and support operations are predicted to occur. The total-body dose to the maximum individual from support facility operations was calculated to be 0.074 millirem to a child in the first year and 0.022 millirem in the tenth year. More than 75 percent of the total-body dose is from tritium; the major dose pathways are the ingestion of vegetables and milk. The maximum organ dose was calculated to be 0.56 millirem to an adult's thyroid in the first year and 0.62 millirem in the tenth year. Iodine-129 contributes more than 90 percent of these doses; the ingestion of vegetables and milk are the major dose pathways.

Population dose from atmospheric releases

The incremental total-body dose to the population within 80 kilometers of the Savannah River Plant due to L-Reactor support facilities was calculated to be 2.8 person-rem in both the first and tenth years. More than 70 percent of the total-body dose is from tritium. Inhalation and the ingestion of vegetables are the major dose pathways. The highest organ doses were 96 person-rem to the thyroid and 27 person-rem to the skin. More than 95 percent of the thyroid dose is from iodine-129 with the ingestion of vegetables being the dominant dose pathway; more than 90 percent of the skin dose is from krypton-85 via exposure to the plume of released radioactivity.

5.1.2.4 Summary - offsite dose commitments from support facility operation

Table 5-13 summarizes the maximum individual dose and population dose from L-Reactor support facilities. The numbers listed as totals for individual and population doses are conservative maximums; to receive these doses, the "composite" individual (or population) would have to occupy several locations simultaneously.

TC | The composite maximum individual dose of 0.087 millirem in the first year and 0.072 millirem in the tenth year is less than 0.1 percent of the average dose of 93 millirem (Du Pont, 1982a) received by an individual living near the SRP site from natural sources. The doses this individual receives are well below DOE protection guides of 500 millirem to the total body and 1500 millirem to other organs (DOE, 1981). The maximum population dose of 8.1 person-rem (tenth year) is about 0.007 percent of the dose of about 109,000 person-rem to the population living within 80 kilometers of the Savannah River Plant and the Beaufort-Jasper and Port Wentworth drinking water population from natural radiation sources.

Table 5-13. Summary of total-body dose commitments
from L-Reactor support facility operation

Source of exposure	1st year		10th year	
	Adult	Child	Adult	Child
MAXIMUM INDIVIDUAL DOSE (millirem per year)				
Atmospheric releases ^a	0.050	0.074	0.015	0.022
Liquid releases	<u>0.022</u>	<u>0.013</u>	<u>0.050</u>	<u>0.050</u>
Total	0.072	0.087	0.065	0.072

Source of exposure	Dose within 80 kilo- meters of SRP		Port Wentworth and Beaufort-Jasper doses	
	1st year	10th year	1st year	10th year

REGIONAL POPULATION DOSE (person-rem per year)				
Atmospheric releases	2.8	2.8	--	--
Liquid releases	<u>0.044</u>	<u>0.048</u>	<u>0.95</u>	<u>5.3</u>
Total	2.8	2.8	0.95	5.3

^aThe location of the maximum individual is where the receptor receives the largest total dose from the L-Reactor plus its support facilities; because of the increase in tritium releases from L-Reactor until equilibrium is reached, this location is different in the first and tenth years.

5.1.2.5 Health effects of support facilities operations

Risk estimators used to project health effects were 120 cancers and 257 genetic effects per 1,000,000 person-rem exposure to the population. Using these estimators and the values for regional doses (Table 5-13), the radiation-induced health effects that might occur eventually as a result of operation of support facilities for L-Reactor (from atmospheric and liquid releases) include a maximum of 0.0004 excess cancer fatality and 0.0007 additional genetic disorder in the population within 80 kilometers of the Savannah River Plant from releases occurring in the first or tenth year of operation. Health effects that might eventually occur in the downstream Savannah River water-consuming populations of Port Wentworth and Beaufort-Jasper include a maximum of 0.0003 and 0.0007 fatal cancer as a result of releases in the first and tenth years, respectively. The maximum incidence of genetic disorders to these populations would be 0.0002 and 0.001 as a result of first- and tenth-year releases, respectively.

CT-1

5.1.2.6 Occupational dose

The operation of L-Reactor support facilities is expected to cause an incremental dose increase of about 291 person-rem in the total onsite occupational dose. The total expected occupational dose from operation of L-Reactor and its support facilities is 360 person-rem (i.e., 69 person-rem for L-Reactor and 291 person-rem from support facilities).

5.1.2.7 Summary - offsite dose commitment from operation of L-Reactor and its support facilities

Table 5-14 summarizes the maximum individual and population dose from release of radioactive materials from L-Reactor (reference case) and its support facilities. The doses listed as totals for both individuals and populations are conservative maximums, as explained in Section 5.1.2.4.

The composite maximum individual dose of 3.6 millirem in the first year of operations is about 26 times less than the average dose of 93 millirem per year received by an individual living near SRP from natural radiation. The total-body dose to both the 80-kilometer and downstream river-water-consuming populations of 36 person-rem (tenth year) is less than 0.03 percent of the approximately 109,000 person-rem received by the 80-kilometer and the downstream river-water-consuming population from natural background radiation sources.

In 1982, radiation exposure rates from 0.14 to 1.09 milliroentgen per day were measured in the uninhabited, privately owned Creek Plantation Swamp to the southeast of the SRP boundary (Du Pont, 1983a). These exposure rates are the result of radiocesium deposition in the swamp, principally during the 1960s. The current inventory of radiocesium in Creek Plantation Swamp is estimated to be about 21 curies. Approximately 6 years after resumed L-Reactor operation, the inventory will reach a maximum of about 23 curies (Appendix D). In the extremely unlikely event that a person should stay in Creek Plantation Swamp for an entire year, he would receive, on the average, an additional total-body dose of approximately 106 ± 22 millirem based on the distribution of radiocesium in the swamp (Hayes, 1982). This situation is not considered credible.

The population doses described above are received by the regional population. Certain radionuclides, primarily tritium, carbon-14, krypton-85, and iodine-129, can be transported through the atmosphere for long distances and can result in doses to the rest of the U.S. population. Most radionuclides in particulate form are deposited in the regional area.

The 100-year environmental dose commitment to the U.S. population beyond 80 kilometers of SRP from the four main radionuclides identified above is summarized in Appendix B. The sum of the doses to the total body from first- and tenth-year operation is about 25 and 48 person-rem, respectively; an additional 1.7 person-rem to the thyroid will result from iodine-129 releases during first or tenth-year operation.

The radiation-induced health effects that might be caused in the U.S. population by the operation of L-Reactor and its support facilities have been

Table 5-14. Summary of maximum individual and regional population total-body dose from the operation of L-Reactor and SRP support facilities for the reference case

Source of exposure	First year	Tenth year
MAXIMUM INDIVIDUAL ADULT DOSE (millirem per year)		
Atmospheric releases	0.10	0.23
Liquid releases	0.029	0.14
Radiocesium transport	<u>3.5</u>	<u>0.31</u>
Total	3.6	0.68

Source of exposure	Dose within 80 kilo- meters of SRP		Port Wentworth and Beaufort-Jasper doses	
	First year	10th year	First year	10th year
REGIONAL POPULATION DOSE (person-rem per year)				
Atmospheric releases	5.8	16.3	-	-
Liquid releases	0.053	0.066	1.7	18.5
Radiocesium transport	<u>9.0</u>	<u>0.80</u>	<u>0.80</u>	<u>0.067</u>
Total	14.9	17.2	2.5	18.6

analyzed by the methods described in the BEIR III Report (NAS, 1980). The estimated health effects due to the first year of L-Reactor and support facilities operations would be about 0.003 premature cancer death and 0.006 genetic disorder; releases during the tenth year of operation would eventually cause about 0.006 premature cancer death and 0.01 genetic disorder.

5.1.2.8 Waste-management operations

Currently, 50 of the 51 large subsurface tanks (Tank 16 is being decommissioned) are used to store the high-level radioactive wastes generated by the SRP chemical separations facilities (F- and H-Areas). Four types of waste tanks are being used to store high-level waste (HLW) (ERDA, 1977). All freshly generated HLW will be processed and stored in Type III tanks, which consist of a tank within a tank; the space between the inner and outer walls is monitored to detect any leaks in the inner wall so corrective action can be taken. The safety and potential environmental risk of constructing and operating the SRP Type IV tanks are discussed in the environmental impact statement prepared for the use of double-wall storage tanks (DOE, 1980).

BH-6

Incremental processing by the chemical separations facilities as a result of L-Reactor operation will generate 1150 to 2300 cubic meters of liquid waste per year. This volume of waste will be concentrated to 380 to 760 cubic meters per year. With this additional volume of waste, a maximum of three tanks per decade of L-Reactor operation would be required, two for fresh waste and one for concentrated waste. However, because the Defense Waste Processing Facility is expected to be immobilizing SRP high-level waste into borosilicate glass by 1989, no new high-level waste tanks are actually expected to be required for L-Reactor operation. The volume of high-level radioactive waste to be generated by chemical processing of L-Reactor material was considered in the Defense Waste Processing Facility EIS (DOE, 1982a).

Operation of the L-Reactor will result in the generation of about 570 cubic meters of low-level and transuranic radioactive solid waste annually from the reactor itself and about 5700 cubic meters, containing about 86,000 curies of radioactivity, from the fuel fabrication and fuel reprocessing areas.

The low-level solid waste from the reactor operations contains both fission products and induced activity. This waste is generated during maintenance work on pipes, valves, instruments, and other reactor components; by the accumulation of radionuclides on the filters for the cooling-water basin; and by the partial disassembly of fuel, target, and control-rod assemblies before they are transported to the fuel reprocessing areas. Solid waste from the reactor consists of stainless-steel end fittings on fuel and target components, aluminum housing tubes, and other miscellaneous reactor parts, including contaminated work clothing and plastic suits.

Work clothing, plastic suits, and other items of a similar nature are packaged in boxes and sealed before their disposal in the SRP Burial Ground. The highly radioactive stainless steel and aluminum parts are placed in shielded casks before transport. The Burial Ground is a 195-acre area near the center of SRP between the F- and H-Separations Areas. At present, about 17,000 cubic meters of solid waste containing 260,000 curies of activity is added to the Burial Ground each year. After L-Reactor restart, the expected input will increase gradually to about 22,650 cubic meters and 350,000 curies of radioactivity per year.

The offsite radiological effects of high-level liquid and solid wastes will be negligible. (Additional information on the SRP waste management operation, including the disposal of SRP high-level and low-level radioactive waste, is contained in the following references: DOE, 1980, 1982a; Du Pont, 1983c, Volume II; and ERDA, 1977.)

5.1.2.9 Accident risks in non-reactor facilities

The resumption of L-Reactor operation will increase the material throughput in both the chemical processing (200-Area) and the fuel fabrication (300-Area) reactor support facilities. Because these facilities were designed to support five production reactors, no changes in the nature of the operations or in their size are required to accommodate L-Reactor.

The consequences of accidents are defined by the inventory of radioactive material in process and available for release at any one time; because these quantities will not be changed appreciably by the resumption of L-Reactor operation, no change in accident types or consequences will result.

The frequency of accidents is related to the material throughput (i.e., increasing the number of hours these facilities operate at full capacity increases the likelihood of accidents occurring). The resumption of L-Reactor operation will increase those frequencies by no more than 33 percent (resulting from the increase in the number of operating reactors from three to four), with a corresponding maximum percentage increase in the present risk (consequence x frequency), exclusive of risks from tritium releases (because L-Reactor will produce only plutonium).

AB-10,
DA-34

The most probable incremental risks from accidents at the L-Reactor support facilities are very nearly equivalent to the incremental impacts from the normal operation of these facilities. The doses from the normal operation of L-Reactor support facilities are listed in Tables B-15 through B-17 (for atmospheric releases) and Tables B-30 through B-33 (for liquid releases). Based on these data, risk to an individual would total about 0.1 millirem per year to the total body and 0.5 millirem per year to the thyroid; population risks total about 8 person-rem per year to the total body and about 100 person-rem to the thyroid.

5.1.3 Preferred alternatives*

The preferred mitigation alternatives for the restart of L-Reactor, which are described in Sections 4.4 and 4.5, include the following:

- Safety systems -- operate L-Reactor with the present confinement system, which consists of a series of filters through which air is exhausted from the reactor building to a tall stack.
- Cooling water -- The preferred cooling-water alternative of the Department of Energy is to construct a 1000-acre lake before L-Reactor resumes operation, to redesign the reactor outfall, and to operate L-Reactor in a way that assures a balanced biological community in the lake as specified in an NPDES permit to be issued by the State of South Carolina. The lake will require an anticipated minimum period of 3 to 5 years to establish and develop a balanced biological community. Initially, L-Reactor will be operated to maintain 32.2°C or less in about 50 percent of the lake. Studies will be conducted to confirm the biological characteristics and the cooling effectiveness of the lake. Following the results of these studies, L-Reactor operations will be adjusted as necessary to assure the continued maintenance of a balanced biological community.
- Disassembly-basin water disposal -- purge disassembly-basin water to the existing L-Reactor seepage basin after deionization and filtration;

*Because this section is new, vertical change bars are not necessary.

continue to study the detritiation of reactor moderator for all SRP reactors.

- 186-Basin sludge removal -- flush the 186-basin sludge (batch discharge) to the process sewer and eventually to Steel Creek after L-Reactor has been shut down and the basin drained; monitor the discharge from the process sewer for total suspended particulates during the flushing in accordance with the NPDES permit; report the findings to SCDHEC after 1 year of resumed operation.

The preferred alternatives will not cause any incremental impacts other than those described in Section 5.1. These impacts are summarized below. Where appropriate, the summaries have been modified to reflect changes resulting from interactions between L-Reactor and incremental impacts.

The preferred cooling-water alternative will cause only minor impacts to other facilities on SRP. These include the sale of timber, the relocation/abandonment of roads, and the relocation of two transmission lines (see Section 4.4.2). The sale, cutting, and removal of marketable timber in the area of the cooling pond on Steel Creek will be administered by the U.S. Forest Service. This will increase revenues from timber sales, but the cooling lake will prevent the reforestation of about 775 acres of uplands. The tie-in of the relocated 115-kilovolt power transmission line will require the shutdown of P-Reactor for a short period. However, the tie-in is expected during a scheduled reactor shutdown as part of routine operation; no special shutdown should be required.

5.1.3.1 Socioeconomics

Approximately 160 employees are expected to be hired by 1984 for existing SRP facilities in support of the resumption of L-Reactor operation. About half have already been hired. In addition, approximately 550 construction personnel will be required for the construction of the cooling lake. Because the number of additional employees to be hired is less than 4 percent of the SRP labor force, and because the inmoving population associated with the potential 330 additional employees is less than 0.1 percent of the indigenous population in the six-county area, no impacts on local communities or services is expected.

5.1.3.2 Nonradioactive effluent discharge

Discharge to seepage basins

Nonradioactive effluents generated in operations involving radioactive materials will be discharged to seepage basins in F-, H-, and M-Areas (Table 5-2). The present discharges to the F- and H-Area seepage basins are not hazardous (under RCRA) except for frequent periods of low pH and infrequent discharges of hazardous levels of mercury and chromium. The mercury levels are associated with the processing of onsite reactor products and radioactive waste management activities; the chromium levels are associated with the processing of offsite fuels, radioactive waste management, and the removal of oxide from onsite target elements. The incremental increases to the F- and H-Area seepage

basins from the operation of L-Reactor are not expected to be hazardous except for low pH and occasional discharges of mercury (H-Area only). Effluent discharged to the M-Area seepage basin frequently meets the RCRA definition of hazardous waste because of pH. Typically, the waste stream contains 1,1,1-trichloroethane, but not at levels considered to be hazardous.

The projected L-Reactor incremental liquid releases to the Separations Areas will be 0.04 cubic meter per minute to the F-Area seepage basins and 0.09 cubic meter per minute to H-Area basins. The chemicals in these releases are expected to increase the concentrations of constituents in the contaminant plume by about 7 percent (Table 5-1). The water quality of Four Mile Creek will be degraded as the ground water flows into the creek through seepage springs in low-lying wetland areas. Concentrations of constituents in the creek water will be increased by about 7 percent. However, drinking-water standards will not be exceeded and the quality of the creek water is expected to be similar to that of the Savannah River below the outfall of C-Reactor.

The green clay has effectively protected the Congaree Formation from contaminants released to the seepage basins in the Separations Areas and is expected to continue to protect the Congaree when L-Reactor is restarted. The thick, low-permeability clay units of the lower Congaree and upper Ellenton Formations will remain effective confining units for the Tuscaloosa, and incremental releases to the Separations Area seepage basins are not expected to contaminate the ground water within this formation.

The L-Reactor incremental liquid releases projected for late 1984 to the Fuel and Target Fabrication Area seepage basin amount to 0.05 cubic meter per minute. By the time of the expected L-Reactor restart (early 1985), the I/R well system would have been operational for about 4 months. Additional fuel and target assemblies for L-Reactor are not expected to be produced until the wastewater-treatment facility is operational in April 1985. Thus, there might be no incremental releases to the seepage basin and Lost Lake. If fuel and targets are produced, the small incremental discharges will have only a minor and local effect on the contaminant levels in the Tertiary ground-water system beneath the seepage areas; the effects will be dissipated during the protracted period of seepage to the water table. The thick, low-permeability clay units of the lower Congaree and upper Ellenton Formations will remain effective confining units for the Tuscaloosa, and incremental releases to the M-Area basin are not likely to contaminate the ground water within this formation. However, the A- and M-Areas ground-water remedial action project is scheduled to be operating by August 1984. The I/R wells, which will have a capacity of at least 12.5 times the incremental release, are expected to intercept seepage from the basin and Lost Lake areas when it reaches the water table in about 10 to 17 years. The I/R system is expected to counter any tendency for increased downward migration of contaminants resulting from L-Reactor incremental pumping. Use of the M-Area seepage basin is scheduled to be discontinued by April 1985, when a wastewater-treatment facility will be in service.

Ash basin

Additional discharges of coal ash will be sluiced (mixed with water and discharged) to the K-Area ash basin for disposal as a result of the production of steam for L-Reactor operation. The additional burning of coal will produce approximately 815 metric tons of ash per year, which will increase the K-Area

steam-plant discharge to the ash basin by about 15 percent. Leachate from the ash basin will enter the shallow ground-water system of the Barnwell Formation, from which it will migrate to Pen Branch; little impact is anticipated.

Effluent treatment processes

Alternatives to the discharge of process wastewaters to the seepage basins in the chemical separations and fuel and target fabrication areas are being investigated, with the intent that these seepage basins will be closed and decommissioned (see Section F.6).

Releases to surface streams

The operation of L-Reactor will cause an incremental increase of about one-third in the direct discharge of liquid effluent from the separations areas to surface streams. As listed in Table 5-5, F-Area will discharge an additional 890 liters per minute to Four Mile Creek; the increment to Four Mile Creek from H-Area will be about 1040 liters per minute (Du Pont, 1982b). Table 5-5 also lists the expected concentrations of pollutants in the liquid effluents to these streams and compares the concentrations to applicable drinking-water standards or water-quality criteria.

At the outfall, these releases are permitted under NPDES and, except for pH, are expected to meet SCDHEC water-quality standards for Class B streams.

5.1.3.3 Atmospheric releases

Incremental impacts of nonradiological atmospheric pollutants will occur because of the increased steam, electricity, and other processes that L-Reactor operation will require. However, these are not expected to cause any violations of regulations or air-quality standards.

Nitrogen oxide (NO_x) releases resulting from L-Reactor operation are higher than other air pollutant emission increases (Table 5-6). Overall, L-Reactor restart will increase future SRP NO_x emissions by about 5 percent. Air emissions permits for the F-, H-, and M-Area facilities have been revised to reflect process changes. Sulfur dioxide and total suspended particulate releases will add about 1 percent. Releases related to L-Reactor operation will contribute 1.1 micrograms per cubic meter NO_x to the ambient air at the SRP boundary. This compares to 15 to 23 micrograms per cubic meter NO_x estimated from all other SRP sources in 1985. Total sulfur dioxide and total suspended particulate releases from L-Reactor restart will add less than 1 gram per cubic meter each.

5.1.3.4 Water usage

Surface water

Only minor amounts of surface water will be consumed by SRP facilities to support L-Reactor operation, because ground water will be the principal source

of process water at these facilities. The K-Reactor steam plant will require an estimated 0.005 cubic meter per second additional water from the Savannah River to produce steam for L-Reactor (Du Pont, 1981).

Ground water

Incremental ground-water pumping from the Tuscaloosa Formation, required to support the resumption of L-Reactor operation, will occur in five areas on SRP; as identified in Table 5-7, these are K-Area (steam plant), the Central Shops, and F-, H-, and M-Areas. The 1985 projected ground-water consumption from the Tuscaloosa at SRP, including that from those areas in support of L-Reactor (0.94 at L-Area + 4.94 total incremental = 5.9 cubic meters per minute), is estimated to be 25.4 cubic meters per minute. This represents a 7-percent increase over the 1982 SRP withdrawal from the Tuscaloosa of 23.8 cubic meters per minute, but a 6-percent decrease from the 1983 withdrawal rate of 27.0 cubic meters per minute (Tables 5-7 and F-10). The withdrawal of Tuscaloosa ground water at the rate of 25.4 cubic meters per minute is expected to have little impact (less than 0.4 meter) on offsite water levels. Beneath the Central Shops and H-Area basins, the head differential between the Tuscaloosa and Congaree is expected to become downward; the differential in A- and M-Areas is expected to become increasingly downward. However, the green clay has a very low permeability and appears to be an effective barrier to the downward migration of pollutants wherever it is present on SRP. The lower Congaree and upper Ellenton clay units act as similar barriers for the Tuscaloosa Aquifer. A new equilibrium piezometric surface is expected to develop quickly in response to the decrease in pumping from 27.0 to 25.4 cubic meters per minute, and the decline in water levels measured in monitoring wells is expected to be arrested.

5.1.3.5 Radiological effects of support facilities

The resumption of L-Reactor operation will result in an increase of about 33 percent in radioactive discharges from the support facilities (i.e., central shops area, heavy-water area, fuel fabrication area, and the separations areas). Releases from support facilities associated with L-Reactor operation will build up gradually; during the first year of L-Reactor operation they will be less than 50 percent of the equilibrium values in succeeding years. However, for the purpose of the present analysis, it is assumed that first-year releases are equal to the expected equilibrium annual average releases.

None of the preferred alternatives will result in additional incremental radiological releases from any of the facilities supporting the operation of L-Reactor. Section 5.1.2 characterizes the radioactive releases from support facilities and presents the radiological impact of the releases on the maximally exposed individual and on population groups. Appendix B contains the methodology of the calculations and detailed dose results, including tables that provide the doses by age groups, organs, and pathways.

The total-body doses received by the maximum individual and regional population from L-Reactor radiological releases under the preferred alternatives are combined with the doses from incremental releases in Table 5-15 (compare with Table 5-14). The composite maximum individual dose of 3.6 millirem in the first year of resumed operation is about 26 times less than the average dose of

Table 5-15. Maximum individual and regional population total-body dose from the operation of L-Reactor and SRP support facilities (preferred alternative)

Source of exposure	1st-year dose	10th-year dose
MAXIMUM INDIVIDUAL ADULT DOSE (millirem per year)		
Atmospheric releases	0.10	0.24
Liquid releases	0.029	0.12
Radiocesium and cobalt transport	3.5	0.31
Total	3.6	0.67

Source of exposure	Dose within 80 kilometers of SRP		Port Wentworth and Beaufort-Jasper dose	
	1st year	10th year	1st year	10th year
REGIONAL POPULATION DOSE (person-rem per year)				
Atmospheric releases	5.8	16.7	--	--
Liquid releases	0.053	0.065	1.6	16.1
Radiocesium and cobalt transport	9.0	0.80	0.80	0.067
Total	14.9	17.6	2.4	16.2

93 millirem per year from natural background radiation received by an individual living near SRP. The total-body dose to both the 80-kilometer and downstream river-water-consuming populations of 33.8 person-rem (tenth year) is about 0.03 percent of the estimated 109,000 person-rem received by the 80-kilometer population and the Beaufort-Jasper and Port Wentworth drinking-water populations from natural sources. These effects are slightly less than those expected under the combination of reference case and incremental releases.

The 100-year environmental dose commitment to the U.S. population beyond 80 kilometers from SRP from tritium, carbon-14, krypton-85, and iodine-129 was calculated as described for the direct discharge of cooling water to Steel Creek. The sum of the doses to the total body from first- and tenth-year operation is about 25 and 49 person-rem, respectively; an additional 1.7 person-rem to the thyroid will result from iodine-129 releases during first- or tenth-year operation.

The radiation-induced health effects that might be caused in the U.S. population by the first-year operation of L-Reactor and its support facilities are estimated to be about 0.003 premature cancer death and 0.006 genetic disorder; during the tenth year of operation, the induced health effects would be about 0.006 premature cancer death and 0.01 genetic disorder.

5.2 CUMULATIVE IMPACTS

This section describes the cumulative impacts of L-Reactor operation when taken in conjunction with the effects from its other SRP facilities and from major facilities near the Savannah River Plant. The major SRP facilities include the operating facilities, the Fuel Materials Facility, and the Defense Waste Processing Facility. Major facilities near the Savannah River Plant include the Vogtle Nuclear Power Plant in Burke County, Georgia, the Urquhart Steam Station at Beech Island, South Carolina, and the Chem-Nuclear Systems, Inc., plant near the site boundary.

5.2.1 Socioeconomics

Given the small number of potential immigrating workers associated with the resumption of L-Reactor operation, potential cumulative socioeconomic impacts depend heavily on the workforce requirements and the schedules of other projects at and near the Savannah River Plant. These projects include the Georgia Power Company's Alvin W. Vogtle Nuclear Power Plant in Burke County, Georgia; capital improvements projects at the Savannah River Plant; the Fuel Materials Facility (FMF) at the Savannah River Plant, which will convert enriched uranium into naval nuclear propulsion fuel form; and the Defense Waste Processing Facility (DWPF), which will immobilize SRP high-level wastes.

The craft construction workforce at the Vogtle Nuclear Power Plant currently is about 6700 and is expected to decline in 1984, coinciding with the buildup of the construction workforce for the FMF. After 1983, the SRP construction labor force is expected to increase due to capital improvements and FMF and DWPF construction. Based on the latest forecast of construction activities, the SRP labor force is expected to increase by 2800 persons by the end of the third quarter of 1984.

Assuming that modeling results of a DWPF scenario--reference immobilization alternative, with the Vogtle project having a peak workforce in 1985 (DOE, 1982a)--are applicable to the cumulative construction worker increase at the Savannah River Plant, about 735 total workers (including overhead personnel) are expected to relocate in the six-county area.

In addition to these 735 construction-related personnel, about 80 L-Reactor support personnel (L-Reactor plus incremental) are expected to relocate in the six-county area by the end of 1984. Thus, the cumulative workforce that might relocate into the six-county area is 815. Table 5-16 lists the projected distribution pattern of the cumulative labor force increase at the Savannah River Plant and summarizes potential socioeconomic impacts.

The cumulative SRP construction and operational workforce increase by the end of 1984 is not expected to have major impacts in the six-county area. The potential relocating workforce and its associated population is expected to account for less than 1 percent of the projected 1984 population of the area. Minor impacts on housing, schools, and other public services and facilities might occur where existing or projected 1984 demands exceed current service

Table 5-16. Cumulative SRP socioeconomic impact on six-county area

Location	Projected 1984 population	Estimated number of relocating personnel	Cumulative SRP population increase		Cumulative SRP school-age children increase	
			Total population	Percent of 1984 population	Total population	Percent of 1984 school population
South Carolina						
Aiken	111,775	402	973	0.9	183	0.8
Allendale	11,220	23	55	0.5	11	0.4
Bamberg	18,870	23	58	0.3	11	0.3
Barnwell	21,520	141	336	1.6	66	1.3
Georgia						
Columbia	44,870	35	83	0.2	16	0.2
Richmond	<u>190,180</u>	<u>191</u>	<u>457</u>	<u>0.2</u>	<u>89</u>	<u>0.3</u>
TOTAL	398,435	815	1,962		376	
AVERAGE				0.5		0.5

General Impacts^a

Land use: Minor impact due to size of potential immigrating population in relation to total population.

Population and fire protection: Minor impact due to relationship of demand of potential immigrating population and demand of existing population.

Water and wastewater treatment: Minor impact due to size of demand and current excess capacity in selected existing system.

Roads and traffic: Minor impacts offsite that can be limited through work shift scheduling.

^aConclusions based on projected immigrating population and data in DOE, 1982a.

capabilities; however, the demands placed on these services by the potential relocating workers and their families will be relatively small in relation to the total indigenous demand.

The greatest effects associated with the multiple projects at the Savannah River Plant will be on the economy of the region. As listed in Table 5-17 these projects are anticipated to provide a total of about 4750 direct and indirect job opportunities and \$40 million in additional direct and indirect annual income based on an estimated \$235 million in direct payroll and overhead expenditures. These benefits, however, will be offset partially by local and state government expenditures to serve the relocating construction and operational workers.

Table 5-17. Cumulative SRP economic impact analysis, end of third quarter 1986

Categories of cost and employment	1986
Employment	
Direct employment	2880
Indirect employment	1875
Income and expenditures	
Additional direct income (current \$ millions)	21
Indirect income (current \$ millions)	19
Local expenditures on materials and services (current \$ million)	57

5.2.2 Surface-water usage

At the Savannah River Plant, the Savannah River supplies water for cooling two production reactors, makeup water for Par Pond (the source of cooling water for P-Reactor), and for use in the coal-fired power plants. For the 3-year period from 1974 to 1976, the withdrawal of water from the river by the Savannah River Plant averaged 20.5 cubic meters per second. This withdrawal represented about 7 percent of the river flow past the Savannah River Plant. The maximum usage during the 3-year period was about 26 cubic meters per second. Essentially all water withdrawn from the river is returned to the river (Du Pont, 1981). Based on Neill and Babcock (1971), the estimated consumptive water use will be 0.85 cubic meter per second each for C-, K-, and L-Reactors and about 1.25 cubic meters per second on the average for P-Reactor.

EL-2

When L-Reactor operation is resumed (reference case) water withdrawal from the river will be increased by about 11 cubic meters per second and the total withdrawal rate for the Savannah River Plant will be about 37 cubic meters per second. Under 7-day, 10-year, low-flow conditions (159 cubic meters per second; Section 3.4.1), the Savannah River Plant will withdraw about 23 percent of the

river flow; under average flow conditions, the Savannah River Plant would withdraw about 13 percent for all its operations.

Two neighboring facilities will also use Savannah River water for cooling. The South Carolina Electric and Gas Company's Urquhart Steam Station, located above the SRP, uses about 7.4 cubic meters per second as once-through cooling water. The Vogtle Nuclear Power Plant, near Hancock Landing, Georgia, is now under construction. When completed, it will use a few cubic meters of river water per second as make-up water for its cooling towers.

5.2.3 Ground-water usage

Two new facilities are under construction at SRP, the Defense Waste Processing Facility (DWPF) and the Naval Reactor Fuel Materials Facility (FMF). The DWPF site, adjoining H-Area to the north, has been cleared and preliminary earthwork completed. Actual construction of the FMF, located in F-Area, has begun.

Current (December 1983) projections of the ground-water requirements for the DWPF and FMF are less than 0.75 cubic meter per minute for the DWPF and 0.2 cubic meter per minute for the FMF. The FMF probably would draw its water from the existing F-Area well field. As many as two wells producing from the Tuscaloosa Formation are currently planned for the DWPF, each well with a capacity of about 3.78 cubic meters per minute. The expected drawdown from these planned wells (about 2 to 3 meters near the center of the cone of depression) would increase the drawdown in F-, H-, and M-Areas. Beneath the seepage basins in these areas, the incremental drawdowns from withdrawal for the DWPF and FMF are calculated to be 0.5, 0.7, and 0.2 meters, respectively. The resultant upward head differential between the Tuscaloosa and the Congaree Formations will decrease accordingly beneath the F-Area basins and will become increasingly downward beneath the other basins in H- and M-Areas (see Table 5-7).

AW-1,
BT-7,
DA-8,
EN-24

The cumulative ground-water consumption from the Tuscaloosa is estimated to be 0.95 cubic meter per minute. Thus, the total SRP consumption will be about 26.4 cubic meters per minute, including all L-Reactor-related and cumulative usage. This projected usage represents an 11-percent increase over the 1982 SRP withdrawal from the Tuscaloosa of 23.8 cubic meters per minute, but a slight decrease from the 1983 withdrawal rate of 27.0 cubic meters per minute (see Table F-10). Computer modeling (Marine and Routt, 1975) indicates that the ground-water flux in the aquifer is about 110 cubic meters per minute throughout a study area including SRP and nearby users (Figures F-25 and F-31). The current ground-water flux through this study area is estimated conservatively to be 51 cubic meters per minute, which is the lower bound estimate. This flux estimate compares with a current, incremental, and cumulative withdrawal rate of about 37.9 cubic meters per minute within the study area (11.5 for offsite users + 26.4 for SRP, including L-Area use, support facility incremental use, and cumulative use; see Section 5.1.1.4 for a discussion of incremental ground-water withdrawal). The total SRP projected pumpage rate from the Tuscaloosa Aquifer of about 26.4 cubic meters per minute compares with 37.8 cubic meters per minute, which Siple (1967) concluded could be pumped at the SRP with no adverse

effects on the pumping capabilities of existing 1960 wells, particularly additional wells if spaced to minimize interference between wells. In 1960, SRP pumpage from the Tuscaloosa was about 18.9 cubic meters per minute. Cumulative impacts on offsite water levels are expected to be small (Table 5-8), about 0.4 meter at Jackson and at the site boundary opposite the A-Area. As shown in Table 5-8, the cumulative drawdowns resulting from pumping at SRP are not expected to increase in relation to the incremental drawdowns. This is because the additional pumping for the FMF and the DWPF will be from locations that are large distances from the nearest site boundary relative to the pumping rate (Siple, 1967).

AW-1,
BT-7,
DA-8,
EN-24

The withdrawal of ground water from the Tuscaloosa Aquifer in support of current and projected SRP operation is not expected to affect either the quality of water or the offsite water levels in the aquifer.

At the recommendation of the U.S. Army Corps of Engineers, a foundation grouting operation was conducted at the Savannah River Plant to improve subsurface conditions (COE, 1952a,b). Operating experience at SRP over the past 30 years has demonstrated that subsidence is not a problem. Available leveling data in the vicinity of SRP do not indicate subsidence (DOE, 1982b). Based on anticipated needs over the next few years, subsidence from withdrawal of ground water from the Tuscaloosa Formation is not expected to affect operations at SRP.

5.2.4 Thermal discharge

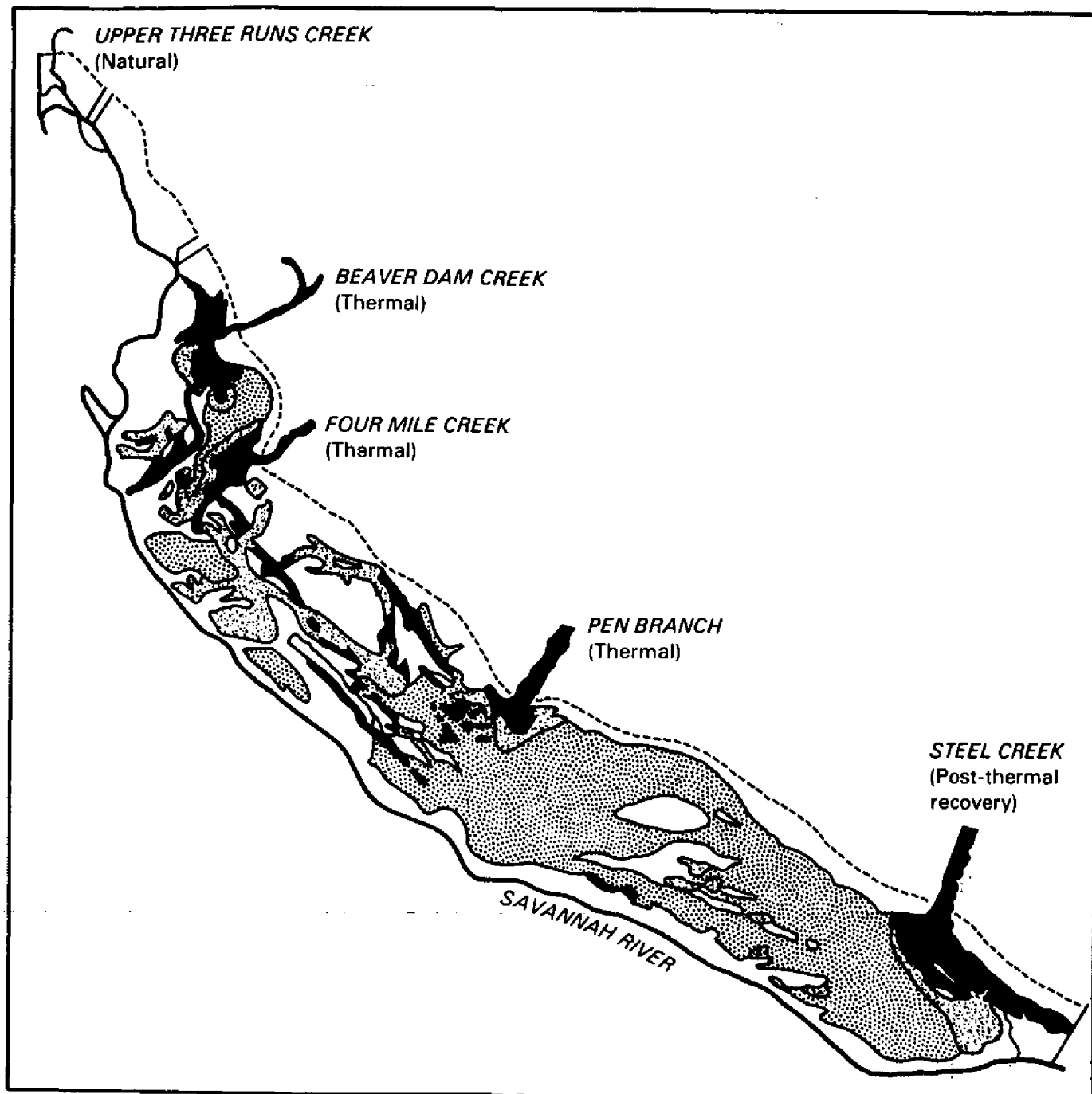
5.2.4.1 Wetlands

Between 1950 and 1970, palustrine vegetated wetlands experienced a net loss of 11 million acres in the conterminous United States (Frayer et al., 1983). The overall net loss was due primarily to agriculture, and consisted of 6 million acres (55 percent) of forested wetland, 4.7 million acres (43 percent) of emergent wetland, and 220 thousand acres (2 percent) of scrub/shrub wetland. Approximately 11.4 percent and 10.1 percent of the total land area of the States of South Carolina and Georgia, respectively, contain bottomland hardwood forests (Clark and Benforado, 1981). The Savannah River watershed includes some 258,000 acres of wetlands dominated by bottomland hardwood forests; of this total, South Carolina contains 138,000 acres and Georgia has 120,000 acres. Between 1960 and 1975, South Carolina lost about 30,000 acres and Georgia lost 141,000 acres of bottomland hardwood forests.

AY-4

The Savannah River Plant contains approximately 37,000 acres of wetlands that include Carolina bays, old farm ponds, impoundments, canals, and riparian habitats associated with creeks and the Savannah River. Cumulative impacts to these wetlands from the Savannah River operations have occurred primarily along streams and in the Savannah River swamp.

Streams that flow through SRP are bordered by 24,607 acres of bottomland hardwood forest (Figure 5-2). Five major streams drain the site and flow to the Savannah River (Table 5-18). Upper Three Runs Creek, which has the largest watershed, is the only major stream on the SRP that has not received reactor cooling-water discharges; it contains 9165 acres of bottomland hardwood wetlands onsite.



Legend:



Adapted from Sharitz et al. (1974).

Figure 5-2. The Savannah River swamp in 1973 after 14 to 19 years of continual thermal loading from reactor discharges.

Table 5-18. Distribution (acres) of forested wetlands for the principal streams of the SRP^a

Stream	Currently thermally impacted	Currently nonthermally impacted	Total
Upper Three Runs Creek	0	9,165	9,165
Four Mile Creek	772	1,176	1,948
Pen Branch	626	1,885	2,511
Steel Creek	0	3,073 ^b	3,073
Lower Three Runs Creek	0	5,574 ^c	5,574
Other ^d	0	2,336	2,336
Total	1,398	23,209	24,607

^aAdapted from Du Pont, 1983b.

^bIncludes the formerly thermal area between L- and P-Reactors.

^cIncludes the formerly thermal area just below Par Pond dam.

^dOther bottomland hardwood wetland areas include areas north of Par Pond (part of the former Lower Three Runs system), interior swamp areas adjacent to the SRP river swamp, wetland SSW of A-Area, part of the Salkahatchie watershed, parts of Boggy Gut Creek watershed, etc.

Currently, about 1400 acres (7 percent) of wetlands associated with the five principal stream corridors are thermally impacted due to SRP operations (Table 5-18). Restart of the L-Reactor (reference case) will impact an additional 420 to 580 acres of wetlands along the Steel Creek corridor and 310 to 420 acres of wetlands in the delta and swamp. The cumulative total acreage of wetlands affected by all SRP operations is approximately 2135 to 2415 acres.

TC

Four Mile Creek and Pen Branch currently receive thermal effluents from C- and K-Reactors, respectively. About 772 acres of thermally impacted bottomland hardwood border Four Mile Creek from C-Reactor to the Savannah River swamp (Figure 5-1). The Four Mile Creek system contains 1948 acres of bottomland hardwood, 40 percent of which occurs along the thermal portion of the stream. Pen Branch has less bottomland hardwood acreage affected by thermal effluents (626 acres) and more total wetlands (2511 acres). Most of the nonthermal Pen Branch system wetlands (75 percent) occur above the confluence with Indian Grave Branch.

Steel Creek and its main tributary, Meyers Branch, have more wetlands acres (3073) and a more varied thermal discharge history than Pen Branch or Four Mile Creek (Figure 5-2). Steel Creek received a wide range of thermal effluent quantities from both P- and L-Reactors from 1954 to 1968. The bottomland hardwood wetlands formerly impacted by L- and P-Reactors have now partially recovered. About 792 acres of bottomland hardwood exist along the Steel Creek corridor from L-Reactor to the swamp. Most of this area (16 percent of the Steel Creek system) was also previously affected by reactor discharges and has partially

recovered to a diverse ecological state. The planned restart of L-Reactor will again impact most of this floodplain corridor.

Lower Three Runs Creek has the second largest watershed. In 1958, the headwaters of this stream were impounded to form Par Pond, a cooling reservoir for R- and P-Reactors. From 1954 to 1958, thermal effluents from R-Reactor were released to Lower Three Runs Creek. Most of the wetland impact areas have now recovered or were inundated by Par Pond. Lower Three Runs Creek contains 5574 acres of bottomland and hardwood forest below the Par Pond dam and swamp forest along the Savannah River.

The historic growth of the Steel Creek delta, as measured by computer digitized aerial photographs taken from 1943 to 1982, show that thermal discharges first affected the canopy between 1955 and 1956; this was more than 1 year after both P- and L-Reactors began releasing hot water to Steel Creek. Rapid vegetation kill and canopy loss occurred at a rate of 50 acres per year from 1956 to 1961 when both reactors discharged to Steel Creek. Delta growth slowed to about 3 acres per year from 1961 to 1966, probably because P-Reactor thermal effluents were diverted to Par Pond in 1963. In 1966, the impact area was nearly maximum at 314 acres (Table 5-19). When L-Reactor discontinued operations in 1968, the swamp canopy began to recover. From 1968 to 1982, about 40 acres of impact zone recovered and new canopy cover was established. Partial canopy recovery occurred in an additional 67 acres of former tree kill.

Table 5-19. Steel Creek delta impacts
(acres)^a

Year	Moderate effect ^b	Intense effect ^c
1951	0	0
1955	0	0
1956	180	0
1961	303	214
1966	307	235
1974	299	210
1982	280	184

^aAdapted from Du Pont (1983b).

^bIncludes partial to total tree canopy losses.

^cIncludes primarily the sedimentation delta and total canopy removal.

Savannah River swamp

The Savannah River floodplain between Augusta, Georgia (River Mile 195), and Ebenezer Landing, Georgia (River Mile 45), contains approximately 130,000 acres of wetlands. The Savannah River swamp provides approximately 10,400 acres of palustrine wetland habitat. It is seasonally separated from the waters of

the Savannah River by a 3-meter-high natural levee (Smith et al., 1981) and receives the waters of several SRP streams. In 1951, prior to the discharge of thermal effluents, a closed canopy of second-growth forest extended over the 10,369-acre swamp (Sharitz et al., 1974). Following the release of heated effluents into the swamp via tributary streams, some trees died in about two-thirds of the area (Figure 5-2).

Between 310 and 420 acres of the Savannah River swamp will be impacted due to the direct discharge of thermal effluent by the L-Reactor (reference case).

This range includes the total area of swamp that was impacted by discharges into Steel Creek during previous operations (Table 5-20). Cumulative thermal impact to the swamp following the resumption of L-Reactor operations should affect about half of the total swamp wetlands.

Table 5-20. Areal extent (acres) of reactor-effluent effects on the Savannah River swamp forest bordering the Savannah River Plant^a

Delta region	Intense effect	Moderate effect	Slight effect	Total area affected
Beaver Dam Creek	110	60		170
Four Mile Creek	70	45		115
Pen Branch	55	50		105
Steel Creek	245	130		375
Total	480	285		765
Total swamp	560	650	3450	4660

^aAdapted from Sharitz et al. (1974).

5.2.4.2 Savannah River

Both the Urquhart Steam Station at Beech Island and operations at the Savannah River Plant discharge cooling-water effluent to the Savannah River from South Carolina. In addition, the Alvin W. Vogtle Nuclear Power Plant, near Hancock Landing, Georgia, will discharge its cooling-tower blowdown to the river. These thermal discharges will be permitted by Georgia under the National Pollutant Discharge Elimination System (NPDES).

As the result of water storage in Clarks Hill Reservoir above Augusta, Georgia, and its mode of discharge, the temperature of the Savannah River is as much as 8°C below the temperature that would occur in the summertime if the reservoir did not exist (Neill and Babcock, 1971). The temperature of the river water generally increases naturally as the water flows from Clarks Hill Reservoir past the Savannah River Plant. The South Carolina Electric and Gas Company's Urquhart Steam Station, located above the Savannah River Plant, discharges about 7.4 cubic meters per second of cooling-water effluent at temperatures as high as 6°C above ambient river temperature. The thermal effluent

raises the temperature of the river by about 0.3°C on the average and by as much as 0.5°C in the summer (Boswell, 1972).

At present, once-through cooling-water effluent is discharged from the Savannah River Plant via three streams--Beaver Dam Creek, Four Mile Creek, and Pen Branch/Steel Creek--to the Savannah River. Beaver Dam Creek has the smallest SRP thermal effluent, which originates about equally in D- and C-Areas. In the future, SRP will also discharge thermal blowdown from the small cooling towers servicing the Fuel Materials Facility and the Defense Waste Processing Facility will be small and will not impact the Savannah River.

TE | The temperature at the mouth of Beaver Dam Creek typically ranges from 5.5°C to 11.1°C above the temperatures of the Savannah River during the warmer months (Du Pont, 1982a).

TE | Four Mile Creek receives once-through cooling-water discharges from C-Reactor. The temperatures of thermal effluent discharged from Four Mile Creek ranges from 16.7° to 19.4°C above Savannah River water temperatures during the late spring and summer months (Du Pont, 1982a).

Pen Branch receives once-through cooling-water effluent from K-Reactor. This effluent is discharged to the Savannah River through the mouth of Steel Creek. The temperature of the water released at about 15.6 cubic meters per second from the mouth of Steel Creek typically is less than 5.6°C above the water temperature of the river during spring and summer. When both K-Reactor and L-Reactor (direct discharge) discharged via the mouth of Steel Creek, the creek-to-river delta-T averaged about 7.2°C during warmer months and ranged to a maximum of 14.7°C and the flow rate to the river averaged about 27.4 cubic meters per second (DOE, 1982a).

The thermal plumes in the Savannah River from Beaver Dam Creek, Four Mile Creek, and Steel Creek will not interact with each other. Analyses of upstream and downstream water temperature data for the 11-year period since L-Reactor was placed on standby (1968 to 1978) suggest that, once in 10 years, a maximum increase of 1.6°C will occur in the Savannah River (fully mixed) water temperature resulting from SRP operations. With the addition of L-Reactor thermal effluent (reference case), once in 10 years the maximum increase is projected to be about 2.3° to 2.4°C; it will probably occur in June, July, or August during periods of low river flow. This increase was exceeded three times (3.2°C) from 1959 to 1963, when four SRP reactors discharged to the river, and once in 1966 (2.7°C) when three reactors discharged to the river. In winter, the maximum increase in river water temperature from the operation of three reactors will be about 0.7° to 1.3°C, depending on flow conditions (Du Pont, 1982a).

FF-12 | The Vogtle Nuclear Power Plant will use natural draft cooling towers to dissipate the heat generated by the two reactor units. The heated cooling-tower blowdown will be discharged to the Savannah River at temperatures below 33°C (Georgia Power Company, 1973). Because the blowdown will be from a single-point discharge pipe at River Mile 150.7 at a rate of only a few cubic meters per second, it is expected that the contribution of heat to the river by the Vogtle Plant will be very small compared to the contribution from C-Reactor via the mouth of Four Mile Creek. No thermal blockage of the Savannah River by the interaction of the Vogtle Plant and Four Mile Creek plumes is anticipated. The plume from Vogtle Plant operations will dissipate quickly. Calculations show

that a plume-river delta-T of 1°C will extend only about 100 meters downriver from the diffuser and the 2.8°C plume-river delta-T will extend less than 20 meters downriver and approximately 30 meters across the 105-meter-wide river (Georgia Power Company, 1973). Thus, the Vogtle plume will have dissipated before reaching the plume from Four Mile Creek at River Mile 150.4.

In conclusion, a zone of passage for anadromous fish and other aquatic organisms will exist in the Savannah River from Steel Creek to Beech Island. Thermal blockage will not occur.

5.2.5 Fisheries

5.2.5.1 Thermal effects

The direct discharge of heated effluent from L-Reactor (reference case) will eliminate most fish from the Steel Creek corridor and from much of the Steel Creek delta. Access to the flood-plain swamp for fish via the mouth of the creek will be blocked. Accordingly, spawning in Steel Creek by anadromous species will be eliminated. In addition, because access to the wetland areas near Boggy Gut Creek will be restricted at times by the thermal plume, spawning in these areas also might be affected.

Heated effluents from C- and K-Reactors and the D-Area powerhouse are discharged currently into Four Mile Creek, and Pen Branch, and Beaver Dam Creek, respectively, rendering these areas unsuitable for spawning by anadromous fishes under normal river flow conditions. Accordingly, direct discharge (reference case) will increase the area of streams and wetlands from which spawning will be eliminated. With the preferred alternative, fish access for spawning will be limited only in the Steel Creek corridor, not in the swamp. Studies in the area have shown that suitable spawning habitat exists in other streams along the Savannah River. In addition, the spawning of many anadromous species (e.g., American shad, striped bass) occurs primarily in the Savannah River itself should not be affected by the thermal discharge from L-Reactor.

Predictive mathematical models and prior experience with L-Reactor operation indicate that direct thermal discharges to the Savannah River from Steel Creek (reference case) will not block the movement of fish past the site in the river. Because there will be no interaction of the L-Reactor plume with that from C-Reactor or from Vogtle Nuclear Power Plant, the cumulative impact from these sources will be minor.

5.2.5.2 Entrainment

Based on ichthyoplankton investigations conducted at the site (see Appendix C), an estimated 17.9×10^6 fish larvae and 18.1×10^6 fish eggs were entrained by SRP cooling-water intakes during 1982. During 1983, these totals were 9.1×10^6 eggs and 28.1×10^6 larvae. This represents about 13 percent of the ichthyoplankton passing the intake canals in the river during 1982, and 7.7 percent in 1983. Under present operating conditions, the flow of cooling water withdrawn from the river is about 26 cubic meters per second. An additional flow of

TC

about 11 cubic meters per second will be required by the L-Reactor. Entrainment losses will increase proportionately. Table 4-1 summarizes projections of cumulative entrainment impacts based on studies conducted in 1977, 1982, and 1983.

The estimated cumulative percentage of fish eggs and larvae passing the Savannah River Plant in the river that will be lost to entrainment by the combined operation of C-, K-, and L-Reactors is about 19 percent.

5.2.5.3 Impingement

TC

The results of the most recent impingement studies conducted at the 1G, 3G, and 5G pumphouses indicate that, under present operating conditions, an average of about 37 fish are impinged each day for an annual total of 13,505 individuals. The highest daily rates occur during periods of high river-water levels when as many as 540 fish have been impinged. The restart of L-Reactor will result in the impingement of an estimated 16 additional fish per day or 5840 per year. During periods of high water, the cumulative total impinged could reach about 104 fish per day, 31 of which would be due to L-Reactor operations.

Surveys of the recreational fishery in the freshwater portions of the Savannah River indicate that the species caught in greatest numbers by anglers are bream, catfish, and crappie. These species comprise about 37 percent of the total number of fish collected during the impingement studies. Using these data, estimates can be made of the numbers of these recreationally important fish that would be lost annually due to impingement. Table 5-21 summarizes these estimates.

Another important sport fish is the largemouth bass. It is the second-most sought-after freshwater species in the Savannah River. However, it is not often caught and, therefore, does not rank highly in the catch statistics. Largemouth bass are impinged at SRP only rarely, comprising 0.3 percent of the total fish collected (i.e., 2 individuals out of 684 total). The projection of annual losses under present operating conditions is 14 fish. The cumulative impingement loss once L-Reactor is operating would be about 21 individuals per year.

Table 5-21. Numbers of fish that would be lost annually due to impingement under average river flow conditions

Species	Percentage of total number of fish impinged	Loss under present operating conditions	Cumulative loss with L-Reactor operational
Bream	25.0	1204	1734
Catfish	4.8	231	333
Crappie	7.3	352	506

5.2.6 Radiological effects

Nuclear facilities within an 80-kilometer radius of the L-Reactor include other currently operating Savannah River Plant facilities, the Alvin W. Vogtle Nuclear Power Plant (under construction), the Barnwell Nuclear Fuel Plant (not now expected to operate), and the Chem-Nuclear Services, Inc. low-level radioactive disposal site. The existing and planned operations of these facilities were reviewed to determine the potential cumulative radiological effects of all the facilities operating together.

Facilities currently operating at the Savannah River Plant include three production reactors, two chemical separations areas, a fuel fabrication facility, waste management facilities, and other support facilities. Future projects include construction and operation of a Fuel Material Facility (FMF), to produce fuel forms for the naval reactor program, and the Defense Waste Processing Facility (DWPF), to be used to immobilize high-level radioactive wastes currently stored in tanks at the Savannah River Plant. The FMF and DWPF are not expected to become operational until the latter half of the 1980s and will have no radiological impact during initial startup of the L-Reactor.

The Alvin W. Vogtle Nuclear Power Plant is being constructed by the Georgia Power Company about 15 kilometers southwest from the L-Reactor. When completed, |TC this plant will have two light-water-cooled power reactors. The Vogtle Power Plant is not expected to reach full operation until the latter part of the 1980s and also will have no radiological impact during the initial startup of L-Reactor.

The Barnwell Nuclear Fuel Plant is located approximately 19 kilometers northeast of L-Reactor. The owners of this facility, Allied-General Nuclear Services, have announced that they do not plan to operate this plant. The normal operation of the Chem-Nuclear Services, Inc. low-level radioactive disposal site does not entail discharges of low-level radioactive material to surface waters or the atmosphere.

The cumulative offsite radiation dose, therefore, is the sum of the doses from L-Reactor and its support facilities, current SRP operation with three reactors, the planned Fuel Materials Facility and Defense Waste Processing Facility at SRP, and the Vogtle Nuclear Power Plant. The total-body doses to the maximally exposed offsite individual and to the population are summarized in Table 5-22 for the reference-case operation of L-Reactor. (Refer to Section 4.1.2.5.) The maximum individual dose is conservative because the defined "composite" individual would have to be a permanent resident of several different locations to receive the dose. The doses shown are for the tenth year of L-Reactor operation when it is expected that all described facilities will be in operation and when radioactive releases from L-Reactor will have reached an equilibrium maximum.

Table 5-22. Cumulative total-body doses from L-Reactor operation and other nearby nuclear facilities^a (reference case)

Source of exposure		Atmospheric releases	Liquid releases	Total
MAXIMUM INDIVIDUAL ADULT DOSE (millirem per year)				
TE	Cs-137 and Co-60 redistribution from Steel Creek	--	0.31	0.31
	L-Reactor and support facilities Savannah River Plant - current operations	0.23	0.14	0.37
	Fuel Materials Facility - SRP ^b	0.81	0.43	1.2
	Defense Waste Processing Facility - SRP	0.000063	--	0.000063
		0.0047	0.0077	0.012
	Vogtle Nuclear Power Plant	0.0060	1.6	1.6
	Total	1.1	2.5	3.5
REGIONAL POPULATION DOSE ^c (person-rem per year)				
A-45	Cs-137 and Co-60 redistribution from Steel Creek	--	0.87	0.87
	L-Reactor and support facilities Savannah River Plant - current operations	16	19	35
	Fuel Materials Facility - SRP ^b	80	40	120
	Defense Waste Processing Facility - SRP	0.0026	--	0.0026
		0.23	1.2	1.4
	Vogtle Nuclear Power Plant	0.024	7.8	7.8
	Total	96	69	165

^aDuring tenth year of L-Reactor operation.

^bAdopted from DOE, 1982b.

^cIncludes doses from water consumed at Beaufort-Jasper and Port Wentworth.

The composite maximum individual dose of 3.5 millirem for the reference case is 26 times less than the average dose of 93 millirem (Du Pont, 1982b) received by an individual living near the SRP site from natural radiation. The composite population dose of 165 person-rem is about 0.15 percent of the exposure of about 109,000 person-rem to the population living within 80 kilometers of the Savannah River Plant and the Beaufort-Jasper and Port Wentworth drinking-water populations from natural radiation sources.

Table 5-23 lists estimated concentrations of radionuclides in the air, milk, and drinking water resulting from routine releases from L-Reactor, total

SRP, and other planned nuclear facilities in the vicinity of SRP for the reference case.

5.2.7 Health effects

The potential radiation-induced health effect for the reference case calculated from the operation of L-Reactor and other nuclear facilities within an 80-kilometer radius (from atmospheric and liquid releases of radioactive materials and redistribution of cobalt-60 and cesium-137 from Steel Creek and downstream water consumption) were calculated by multiplying the regional population doses (from Table 5-23) by the following risk estimators: 120 cancers and 257 genetic effects per 1,000,000 person-rem exposure. The projected cumulative health effects that might eventually occur as a result of the operation of L-Reactor and other nearby nuclear facilities include a maximum of 0.02 excess cancer fatality and 0.04 genetic disorder in the tenth year of operations.

CT-1

5.2.8 Preferred alternatives*

This section describes the cumulative impacts of L-Reactor operation with the preferred alternatives, taken in conjunction with the effects from other SRP facilities and from major facilities near SRP.

5.2.8.1 Socioeconomics

The SRP construction labor force is expected to increase by about 2800 persons after 1983 due to capital improvements and the construction of the Fuel Materials Facility (FMF) and the Defense Waste Processing Facility (DWPF). The DWPF site, adjoining H-Area to the north, has been cleared and preliminary earthwork has been completed. Actual construction of the FMF, located in F-Area, has begun. In addition, construction labor force requirements for the 1000-acre cooling lake are estimated to be about 550 persons. Approximately one-fourth of the total increase of the SRP construction labor force, or about 800 workers, are expected to relocate into the six-county area. In addition, about 80 L-Reactor support personnel are expected to relocate into the six-county area by the end of 1984.

The cumulative SRP construction and operational workforce increase by the end of 1984 is not expected to have major impacts in the six-county area and will be only slightly higher than cumulative impacts for the restart of L-Reactor with direct discharge (Section 5.2.1). Economic benefits will also be higher due to the temporary increase in construction employment for the cooling lake.

*Because this section is new, vertical change bars are not necessary.

Table 5-23. Estimated annual average concentrations of radionuclides in air, milk, and water from routine operating (reference case) releases

Nuclide	Concentration							
	Co-60 and Cs-137		L-RX	L-SUPP	SRP	DWPF	Vogtle	Total
	1st yr	10th yr	10th yr	10th yr	10th yr ^b	10th yr	10th yr	10th yr
IN MILK FROM ATMOSPHERIC RELEASES (MAXIMUM AT PLANT BOUNDARY), pCi/liter								
H-3	--	--	7.0×10^2	5.3×10	3.2×10^3	2.2×10^{-1}	--	3.9×10^3
I-131	--	--	1.8×10^{-3}	1.2×10^{-3}	1.1×10^{-2}	--	3.6×10^{-1}	3.7×10^{-1}
IN AIR FROM ATMOSPHERIC RELEASES (MAXIMUM AT PLANT BOUNDARY), pCi/m ³								
H-3	--	--	4.4×10	3.3	2.0×10^2	1.4×10^{-2}	--	2.4×10^2
C-14	--	--	9.3×10^{-3}	2.5×10^{-3}	3.4×10^{-2}	--	--	4.6×10^{-2}
Ar-41	--	--	8.3	--	1.4×10^1	--	--	2.3×10^1
IN RIVER WATER BELOW PLANT, pCi/liter								
H-3	--	--	1.0×10^3	4.1×10^2	3.0×10^3	9.2×10^1	1.5×10^2	4.7×10^3
Co-60	2.7×10^{-2}	8.6×10^{-4}	4.9×10^{-3}	3.6×10^{-3}	2.3×10^{-2}	9.4×10^{-12}	--	3.2×10^{-2}
Sr-90	--	--	1.2×10^{-2}	6.7×10^{-3}	4.8×10^{-2}	2.5×10^{-6}	1.7×10^{-5}	6.7×10^{-2}
Cs-137	4.8×10^{-1}	4.2×10^{-2}	4.4×10^{-5}	2.1×10^{-3}	2.4×10^{-2}	5.5×10^{-10}	1.6×10^{-1}	2.3×10^{-1}
IN PORT WENTWORTH DRINKING WATER, pCi/liter								
H-3	--	--	1.0×10^3	4.1×10^2	3.0×10^3	9.2×10	1.5×10^2	4.7×10^3
Co-60 ^a	2.7×10^{-2}	8.6×10^{-4}	4.9×10^{-3}	3.6×10^{-3}	2.3×10^{-2}	9.4×10^{-12}	--	3.2×10^{-2}
Sr-90	--	--	1.2×10^{-2}	6.7×10^{-3}	4.8×10^{-2}	2.5×10^{-6}	1.7×10^{-5}	6.7×10^{-2}
Cs-137	9.2×10^{-2}	8.3×10^{-3}	8.7×10^{-6}	4.1×10^{-4}	4.7×10^{-3}	1.1×10^{-10}	3.2×10^{-2}	4.5×10^{-2}
IN BEAUFORT-JASPER DRINKING WATER, pCi/liter								
H-3	--	--	1.0×10^3	4.1×10^2	3.0×10^3	9.2×10^1	1.5×10^2	4.7×10^3
Co-60 ^a	2.7×10^{-2}	8.6×10^{-4}	4.9×10^{-3}	3.6×10^{-3}	2.3×10^{-2}	9.4×10^{-12}	--	3.2×10^{-2}
Sr-90	--	--	1.2×10^{-2}	6.7×10^{-3}	4.8×10^{-2}	2.5×10^{-6}	1.7×10^{-5}	6.7×10^{-2}
Cs-137	1.2×10^{-2}	1.0×10^{-3}	1.1×10^{-6}	5.1×10^{-5}	5.9×10^{-4}	1.3×10^{-11}	3.9×10^{-3}	5.5×10^{-3}

^aCs-137 concentrations in Port Wentworth and Beaufort-Jasper water were calculated by applying factors recommended by D. W. Hayes and A. L. Boni (memorandum from D. W. Hayes and A. L. Boni to J. C. Corey, "Cs-137 in the Savannah River and the Beaufort-Jasper and Port Wentworth Water Treatment Plants," January 10, 1983). These factors were not applied to other radionuclides.

^bRepresents current operation.

5.2.8.2 Surface-water usage

At the Savannah River Plant, the Savannah River supplies water for cooling two production reactors, makeup water for Par Pond (the source of cooling water for P-Reactor), and for use in the coal-fired power plants. For the 3-year period from 1974 to 1976, the maximum withdrawal rate was 26 cubic meters per second. When L-Reactor operation resumes, water withdrawal from the river will increase by about 11 cubic meters per second; the total withdrawal rate for the Plant will be about 37 cubic meters per second. Under 7-day, 10-year, low-flow conditions (159 cubic meters per second; Section 3.4.1), the Savannah River Plant will withdraw about 23 percent of the river flow; under average flow conditions, the Plant will withdraw about 13 percent for all its operations.

Essentially all water withdrawn from the river is returned to the river. The estimated consumption of water will be about 1.25 cubic meters per second for L-Reactor (Neill and Babcock, 1971). This compares with a consumption of about 1.25 cubic meters per second for Par Pond; the consumption for C- and K-Reactors is about 0.85 cubic meter per second each.

Two neighboring facilities will also use Savannah River water for cooling. The South Carolina Electric and Gas Company's Urquhart Steam Station, located above the SRP, uses about 7.4 cubic meters per second as once-through cooling water. The Vogtle Nuclear Power Plant, near Hancock Landing, Georgia, is now under construction. When completed, it will use a few cubic meters of river water per second as makeup water for its cooling towers.

5.2.8.3 Ground-water use

Current projections of ground-water requirements are less than 0.75 cubic meter per minute for the DWPF and 0.2 cubic meter per minute for the FMF. The upward head differential between the Tuscaloosa and Congaree Formations will decrease beneath the F-Area basins and will become increasingly downward beneath the other basins in H- and M-Areas (see Table 5-7) as the result of this increased pumping.

The cumulative ground-water consumption from the Tuscaloosa as the result of SRP operations is estimated to be 0.95 cubic meter per minute. Thus, the total SRP consumption will be about 26.4 cubic meters per minute, including all L-Reactor-related and cumulative usage. This projected usage represents an 11-percent increase over the 1982 SRP withdrawal from the Tuscaloosa of 23.8 cubic meters per minute, but a slight decrease from the 1983 withdrawal rate of 27.0 cubic meters per minute (see Table F-10). Cumulative impacts on offsite water levels are expected to be small (Table 5-8), about 0.4 meter at Jackson and at the site boundary opposite the A-Area. As shown in Table 5-8, the cumulative drawdowns resulting from pumping at SRP are not expected to increase in relation to the incremental drawdowns. This is because the additional pumping for the FMF and the DWPF will be from locations that are long distances from the nearest site boundary relative to the pumping rate (Siple, 1967).

Operating experience at the SRP over the past 30 years has demonstrated that subsidence is not a problem. Available leveling data in the vicinity of

SRP do not indicate subsidence (DOE, 1982b). Based on anticipated needs over the next few years, subsidence from the withdrawal of ground water from the Tuscaloosa Formation is not expected to affect operations at SRP.

5.2.8.4 Thermal discharge

Wetlands

Steel Creek and its main tributary, Meyers Branch, have more wetlands acres (3073) and a more varied thermal discharge history than Pen Branch or Four Mile Creek. Steel Creek received a wide range of thermal effluent quantities from both P- and L-Reactors from 1954 to 1968. The bottomland hardwood wetlands that were affected during those years have partially recovered. About 790 acres of bottomland hardwood exist along the Steel Creek corridor from L-Reactor to the swamp. Most of this area (16 percent of the Steel Creek system) was also previously affected by reactor discharges and has partially recovered to a diverse ecological state. The planned restart of L-Reactor will produce renewed adverse impacts on most of this floodplain corridor.

Currently, about 1400 acres (7 percent) of wetlands associated with the five principal SRP stream corridors receive thermal impacts due to SRP operations (Table 5-18). The restart of L-Reactor will impact an additional 520 to 680 acres of wetlands and 775 acres of uplands. The cumulative total acreage of wetlands along streams affected by all SRP operations (including L-Reactor) is approximately 2135 to 2415 acres.

The Savannah River floodplain between Augusta, Georgia (River Mile 195), and Ebenezer Landing, Georgia (River Mile 45), contains approximately 130,000 acres of wetlands. The Savannah River swamp provides approximately 10,400 acres of palustrine wetland habitat; it is seasonally separated from the waters of the Savannah River by a 3-meter-high natural levee (Smith et al., 1981) and receives the waters of several SRP streams. In 1951, before the discharge of any thermal effluents, a closed canopy of second-growth forest extended over the 10,369-acre swamp (Sharitz et al., 1974). Following the release of heated effluents into the swamp via tributary streams, some trees died in about two-thirds of the area (Figure 5-2).

The historic growth of the Steel Creek delta in the Savannah River swamp, as measured by computer digitization of aerial photographs taken from 1943 to 1982, shows that thermal discharges first affected the canopy between 1955 and 1956; this was more than 1 year after both P- and L-Reactors began releasing hot water to Steel Creek. In 1966, the impact area was nearly maximum at 314 acres (Table 5-19). When L-Reactor discontinued operations in 1968, the swamp canopy began to recover. From 1968 to 1982, about 40 acres of impact zone recovered and new canopy cover was established. Partial canopy recovery occurred in an additional 67 acres of former tree kill.

With the preferred cooling-water alternative, between 215 and 335 acres of the Savannah River swamp at and adjacent to the Steel Creek delta, respectively, will be impacted by the flow caused by discharges from the cooling lake. Cumulative thermal impacts to the swamp following the resumption of L-Reactor operation should affect about 40 percent of the total swamp wetlands at SRP.

Savannah River

As the result of water storage in the Clarks Hill Reservoir above Augusta, Georgia, and its mode of discharge, the temperature of the Savannah River is as much as 8°C below the temperature that would occur in the summertime if the reservoir did not exist (Neill and Babcock, 1971). The temperature of the river water generally increases naturally as the water flows from Clarks Hill Reservoir past the Savannah River Plant. The Urquhart Steam Station above the Savannah River Plant discharges about 7.4 cubic meters per second of cooling-water effluent at temperatures as high as 6°C above ambient river temperature; this effluent raises the temperature of the river by about 0.3°C on the average and by as much as 0.5°C in the summer (Boswell, 1972).

At present, once-through cooling-water effluent is discharged from the Savannah River Plant via three streams--Beaver Dam Creek, Four Mile Creek, and Pen Branch/Steel Creek--to the Savannah River. Beaver Dam Creek receives the smallest amount of thermal effluent, which originates about equally in D- and C-Areas. In the future, SRP will also discharge thermal blowdown from the small cooling towers servicing the Fuel Materials Facility and the Defense Waste Processing Facility; this will not affect the Savannah River.

Pen Branch receives once-through cooling-water effluent from K-Reactor. This effluent is discharged to the Savannah River through the mouth of Steel Creek. The temperature of the water released at about 15.6 cubic meters per second from the mouth of Steel Creek typically is less than 5.6°C above the water temperature of the river during spring and summer. When both K-Reactor and L-Reactor (preferred alternative) discharge via the mouth of Steel Creek, the temperature will be about 4°C, but the flow rate to the river will average about 27.4 cubic meters per second. |T(

Analyses of upstream and downstream water temperature data for the 11-year period since L-Reactor was placed on standby (1968 to 1978) suggest that, once in 10 years, a maximum increase of 1.6°C resulting from SRP operations will occur in the (fully mixed) water temperature of the Savannah River. With the addition of L-Reactor thermal effluent, the once-in-10-year maximum increase is not projected to change. With the preferred cooling-water alternative, the temperature at the mouth of Steel Creek contributed by L-Reactor will only be within about 1°C of ambient in the summer.

The Vogtle Nuclear Power Plant will use natural-draft cooling towers to dissipate the heat generated by its two reactor units. The heated cooling-tower blowdown will be discharged to the Savannah River at temperatures below 33°C (Georgia Power Company, 1973). The contribution of heat to the river by the Vogtle Plant will be very small compared to the contribution from C-Reactor via the mouth of Four Mile Creek. No thermal blockage of the Savannah River by any interaction of the Vogtle Plant and Four Mile Creek plumes is anticipated.

In conclusion, a zone of passage for anadromous fish and other aquatic organisms will exist in the Savannah River from Steel Creek to Beech Island. Thermal blockage will not occur.

5.2.8.5 Fisheries

The preferred alternative (a 1000-acre lake) would not pose any adverse thermal impacts to fishes in the delta area or at the mouth of Steel Creek during spring or summer months, because the temperatures would be 1°C to 3°C above ambient. Warmer conditions during the winter months from Road A to the mouth of Steel Creek (7°C to 9°C above ambient) could concentrate fish near the mouth of the creek. This alternative would not adversely affect access and spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta.

Currently, heated effluents from C- and K-Reactors and the D-Area powerhouse are discharged into Four Mile Creek, Pen Branch, and Beaver Dam Creek, respectively, rendering these areas unsuitable for spawning by anadromous fishes under normal river flow conditions. With the preferred alternative, fish access for spawning will be limited only in the Steel Creek corridor, not in the swamp. Studies in the area have shown that suitable spawning habitat exists in other streams along the Savannah River. In addition, the spawning of many anadromous species (e.g., American shad, striped bass) occurs primarily in the Savannah River itself and will not be affected by the thermal discharge from L-Reactor. Thermal effluent from L-Reactor will not block the movement of fish past the Plant in the river.

Because there will be no interaction of the L-Reactor plume with that from C-Reactor or from Vogtle Nuclear Power Plant, the cumulative impact from these sources will be negligible.

5.2.8.6 Entrainment

Based on ichthyoplankton investigations conducted at the site (see Appendix C), an estimated 17.9×10^6 fish larvae and 18.1×10^6 fish eggs were entrained by SRP cooling-water intakes during 1982. During 1983, these totals were 9.1×10^6 eggs and 28.1×10^6 larvae. This represents about 13 percent of the ichthyoplankton passing the intake canals in the river during 1982, and 7.7 percent in 1983. Under present operating conditions, the flow of cooling water withdrawn from the river is about 26 cubic meters per second. An additional flow of about 11 cubic meters per second will be required by the L-Reactor. Entrainment losses will increase proportionately. Table 4-1 summarizes projections of cumulative entrainment impacts based on studies conducted in 1977, 1982, and 1983.

The estimated cumulative percentage of fish eggs and larvae passing the Savannah River Plant in the river that will be lost to entrainment by the combined operation of C-, K-, and L-Reactors is about 19 percent.

5.2.8.7 Impingement

The results of the most recent impingement studies conducted at the 1G, 3G, and 5G pumphouses indicate that, under present operating conditions, an average

of about 37 fish are impinged each day for an annual total of 13,505 individuals. The highest daily rates occur during periods of high river-water levels when as many as 540 fish have been impinged. The restart of L-Reactor will result in the impingement of an estimated 16 additional fish per day or 5840 per year. During periods of high water, the cumulative total impinged could reach about 104 fish per day, 31 of which would be due to L-Reactor operations.

Surveys of the recreational fishery in the freshwater portions of the Savannah River indicate that the species caught in greatest numbers by anglers are bream, catfish, and crappie. These species comprise about 37 percent of the total number of fish collected during the impingement studies. Using these data, estimates can be made of the numbers of these recreationally important fish that would be lost annually due to impingement. Table 5-21 summarizes these estimates.

Another important sport fish is the largemouth bass. It is the second-most sought-after freshwater species in the Savannah River. However, it is not often caught and, therefore, does not rank highly in the catch statistics. Largemouth bass are impinged at SRP only rarely, comprising 0.3 percent of the total fish collected (i.e., 2 individuals out of 684 total). The projection of annual losses under present operating conditions is 14 fish. The cumulative impingement loss once L-Reactor is operating would be about 21 individuals per year.

5.2.8.8 Radiological effects

Nuclear facilities within an 80-kilometer radius of the L-Reactor include other currently operating Savannah River Plant facilities, the Alvin W. Vogtle Nuclear Power Plant (under construction), the Barnwell Nuclear Fuel Plant (not now expected to operate), and the Chem-Nuclear Services, Inc., low-level radioactive disposal site. The existing and planned operations of these facilities were reviewed to determine the potential cumulative radiological effects of all the facilities operating together.

Facilities currently operating at the Savannah River Plant include three production reactors, two chemical separations areas, a fuel fabrication facility, waste management facilities, and other support facilities. Future projects include the construction and operation of the FMF to produce fuel forms for the naval reactor program, and the DWPF to immobilize high-level radioactive wastes currently stored in tanks at the Plant. The FMF and DWPF are not expected to become operational until the latter half of the 1980s; they will have no radiological impact during the initial startup of L-Reactor.

The cumulative offsite radiation dose is the sum of the doses from L-Reactor (under the preferred alternatives) and its support facilities, current SRP operation with three reactors, the planned Fuel Materials Facility and Defense Waste Processing Facility, and the Vogtle Nuclear Power Plant. The total-body doses to the maximally exposed offsite individual and to the population are summarized in Table 5-24 (compare with Table 5-22) for the operation of L-Reactor with the preferred cooling-water and disassembly-basin purge water alternatives. The maximum individual dose is conservative because the defined "composite" individual would have to be a permanent resident of several different locations to receive the dose. The doses shown are for the tenth year of

L-Reactor operation, when all described facilities are expected to be in operation and when radioactive releases from L-Reactor will have reached an equilibrium maximum.

The composite maximum individual dose of 3.5 millirem for operation with the preferred alternatives is 27 times less than the average dose of 93 millirem (Du Pont, 1982b) received by an individual living near the site from natural radiation. The composite population dose of 163 person-rem is about 0.15 percent of the exposure of about 109,000 person-rem from natural radiation sources to the population living within 80 kilometers of the Savannah River Plant and the Beaufort-Jasper and Port Wentworth drinking-water populations.

The potential radiation-induced health effects calculated from the operation of L-Reactor and other nuclear facilities within an 80-kilometer radius (from atmospheric and liquid releases of radioactive materials and redistribution of cobalt-60 and cesium-137 from Steel Creek and downstream water consumption) were calculated by multiplying the regional population doses (from Table 5-24) by the following risk estimators: 120 cancers and 257 genetic effects per 1,000,000 person-rem exposure. The projected health effects for operation with the preferred alternatives are a maximum of 0.02 excess cancer fatality from tenth-year operations and 0.04 genetic disorder in the tenth year of L-Reactor operation.

5.3 INCREMENTAL IMPACTS OF THE NO-ACTION ALTERNATIVE

K-Area would supply steam to L-Area as it is being maintained in a standby mode. K-Area would burn about 10 percent more coal and, consequently, the discharge to the K-Area ash basin will increase by about 10 percent over the L-Reactor standby phase. Leachate from the ash basin will enter the shallow ground-water system of the Barnwell Formation and migrate to Pen Branch.

The K-Area steam plant will use an additional 0.005 cubic meter of water per second from the Savannah River and an additional 0.002 cubic meter of ground water per second from the Tuscaloosa Formation to supply L-Area with steam.

Maintaining L-Reactor in a standby mode will have little or no effect on the operation of the SRP facilities (fuel fabrication, chemical separations, waste management, etc.) that support the operating reactors.

Table 5-24. Cumulative total-body doses from L-Reactor operation and other nearby nuclear facilities (preferred alternative)^a

Source of exposure	Atmospheric releases	Liquid releases	Total
MAXIMUM INDIVIDUAL ADULT DOSE (millirem per year)			
Cs-137 and Co-60 redistribution from Steel Creek	--	0.31	0.31
L-Reactor and support facilities	0.24	0.12	0.36
Savannah River Plant - current operations	0.81	0.43	1.2
Fuel Materials Facility - SRP ^b	0.000063	--	0.000063
Defense Waste Processing Facility - SRP	0.0047	0.0077	0.012
Vogtle Nuclear Power Plant	0.0060	1.6	1.6
Total	1.1	2.5	3.5
REGIONAL POPULATION DOSE ^c (person-rem per year)			
Cs-137 and Co-60 redistribution from Steel Creek	--	0.87	0.87
L-Reactor and support facilities	17	16	33
Savannah River Plant - current operations	80	40	120
Fuel Materials Facility - SRP ^b	0.0026	--	0.0026
Defense Waste Processing Facility - SRP	0.23	1.2	1.4
Vogtle Nuclear Power Plant	0.024	7.8	7.8
Total	97	66	163

^aDuring tenth year of L-Reactor operation.

^bAdopted from DOE, 1982b.

^cIncludes doses from water consumed at Beaufort-Jasper and Port Wentworth.

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6 STUDIES AND MONITORING

Since 1951 (before the Savannah River Plant (SRP) began operation), an intensive surveillance program has been maintained to monitor the compositions of effluents from the SRP facility, to measure radioisotope concentrations in the plant environs, to assess the ecological health of the overall SRP environment, and to determine compliance with applicable standards. The results of these environmental monitoring programs are reported annually to the public (e.g., Du Pont, 1983a). Section 6.1 describes the scope of these ongoing programs; Figure 6-1 shows the locations of monitoring stations. In addition, Section 6.1 summarizes two special site-wide study programs that reflect commitments made under a Memorandum of Understanding between the U.S. Department of Energy (DOE) and the State of South Carolina. Environmental monitoring programs specifically related to restart and operation of the L-Reactor are described in Section 6.2.

6.1 SRP MONITORING PROGRAMS

6.1.1 Radiological monitoring programs

The program includes the monitoring of air on and off the site, water from SRP streams and the Savannah River, the SRP ground water, and samples of soil, vegetation, food, drinking water, animals, and fish for their radionuclide content. In addition, aerial radiological surveys of the Savannah River Plant and surrounding areas are conducted periodically by the DOE Remote Sensing Laboratory, operated by EG&G. Independent radiological monitoring programs are also conducted by the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Department of Natural Resources (GDNR).

BF-3

Air

Concentrations of radioactive materials in the atmosphere and rainwater are measured at 13 monitoring stations near the SRP perimeter and at 12 stations approximately 40 kilometers from the center of the site. Additional air monitoring stations are located at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina. These latter stations serve as reference points for determining background conditions. This system permits comprehensive surveillance of atmospheric radioactivity and makes it possible to differentiate between worldwide fallout and SRP releases.

SCDHEC independently monitors levels of alpha, beta, and gamma radioactivity on a biweekly frequency at six locations in the SRP vicinity. GDNR monitors concentrations of alpha, beta, and gamma radioactivity monthly at three locations. In addition, GDNR monitors quarterly for plutonium-strontium composite concentrations at these three locations. Air sample concentrations by both agencies are consistent with SRP data from comparable monitoring locations.

BF-3

SRP measures radiation levels continuously with thermoluminescent dosimeters (TLDs) at 165 locations, in a 20,700-square-kilometer area around Savannah River Plant (Figure 6-2).

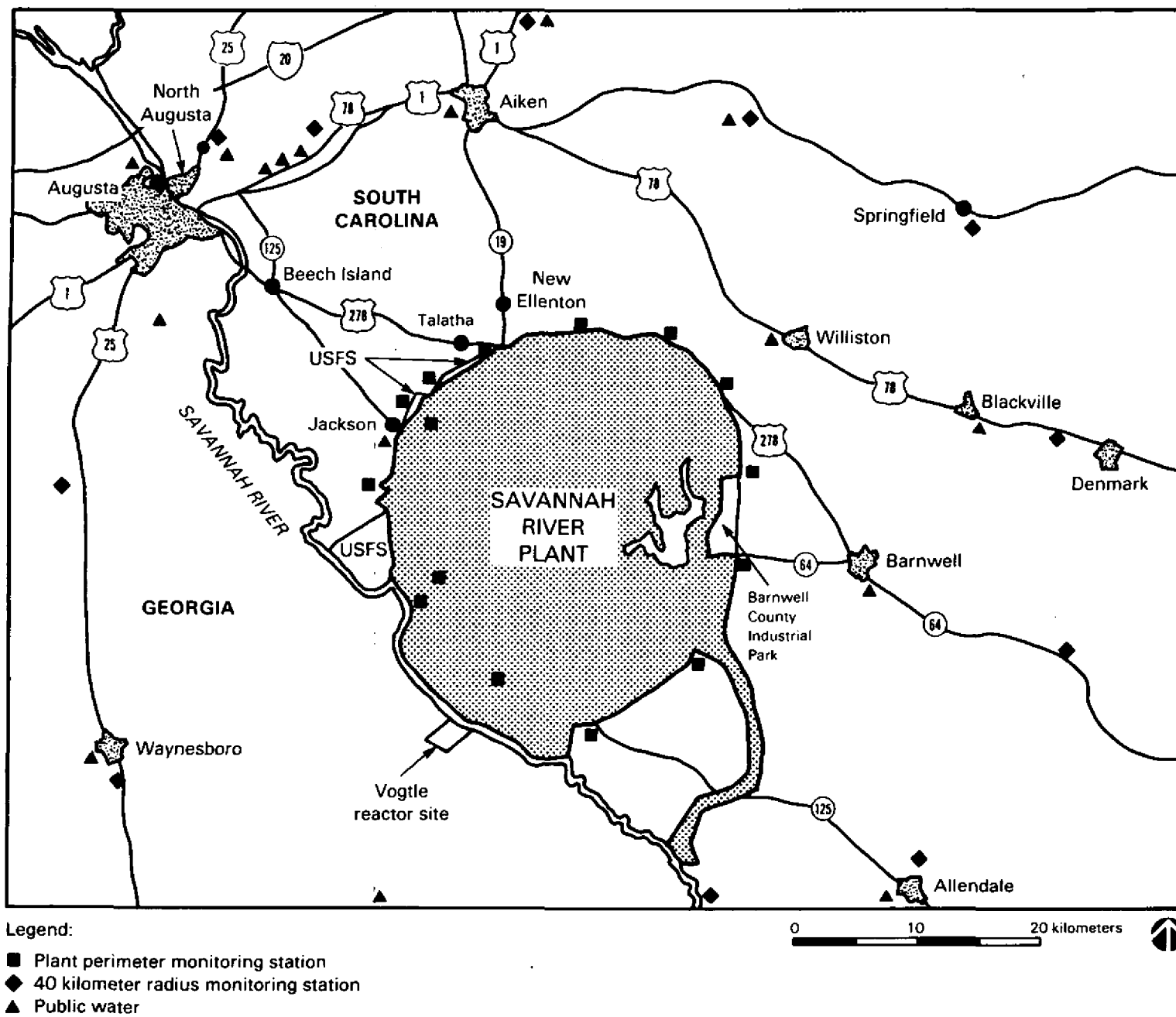


Figure 6-1. Continuous air monitoring stations and public water sample locations.

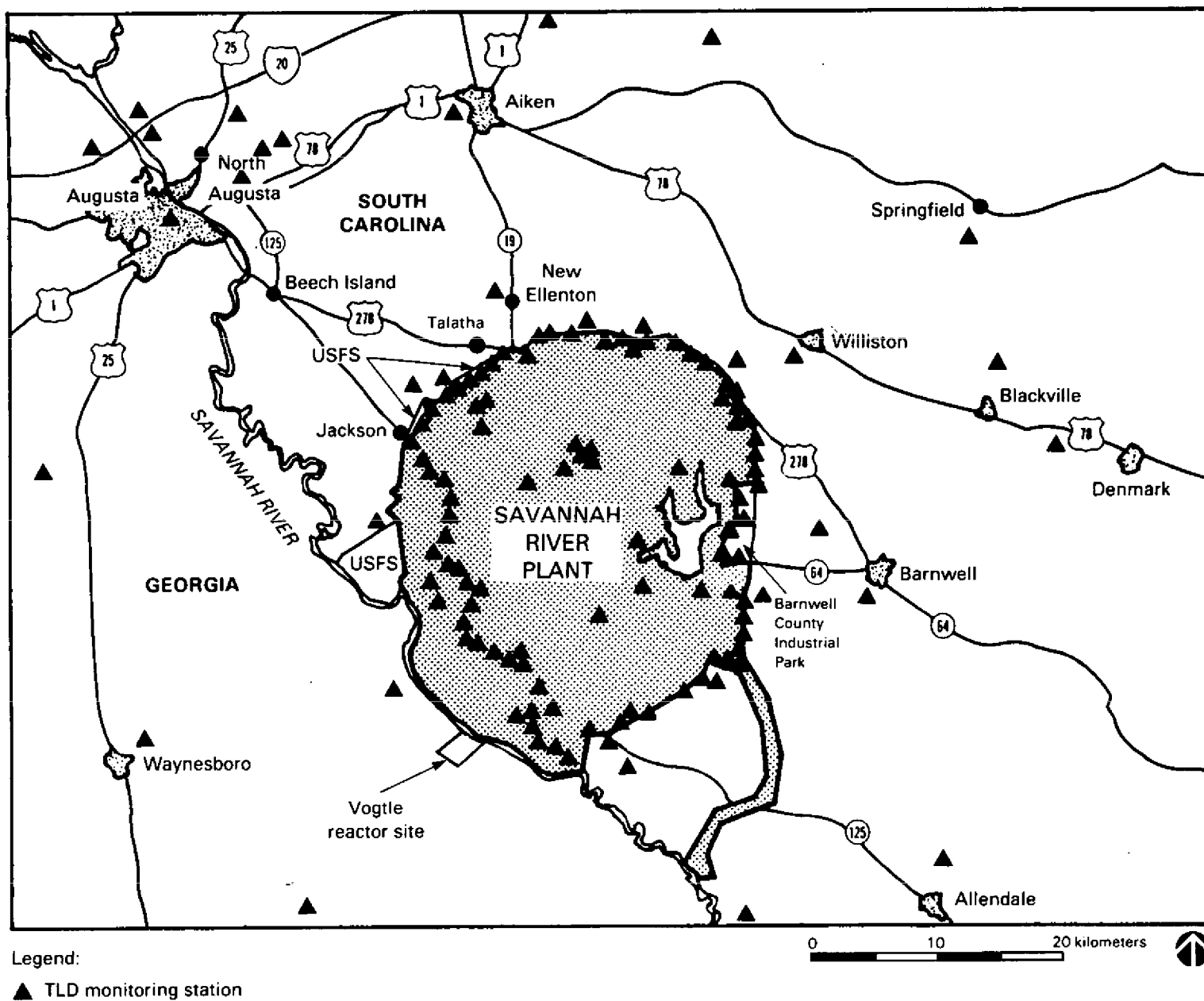


Figure 6-2. TLD monitoring stations.

Additional TLD measurements are made by SCDHEC at 27 locations, principally around the Chem-Nuclear Services, Inc., facility near Barnwell. TLD measurements made quarterly by SCDHEC were consistent with SRP data at select locations from 1974 to 1982.

BF-3

GDNR measures TLD values on a quarterly frequency in Georgia near SRP at 25 locations. TLD measurements made by GDNR during the 1980-1982 period were approximately 60 percent lower than TLD measurements by SRP. These discrepancies can be attributed to the locations of the dosimeters or to the type of dosimeter. GDNR intends to correct these reported TLD measurements (GDNR, 1983).

Savannah River

The site is drained by five streams that flow to the Savannah River. Releases to these onsite streams are monitored for radioactivity. Weekly water samples are collected at five river locations above, adjacent to, and below Savannah River Plant. The samples are analyzed for alpha, nonvolatile beta, and a large number of specific radioisotopes, including tritium and cesium-137.

SCDHEC collects samples at six river locations ranging from North Augusta, South Carolina, to the Beaufort-Jasper water-treatment facility below SRP; these samples are monitored at varying frequencies for concentrations of alpha, nonvolatile beta, gamma, and tritium. Tritium concentrations in the Savannah River at the U.S. Highway 301 bridge and at the Beaufort-Jasper Water Treatment Plant were consistent with SRP data from 1975 to 1982.

BF-3

GDNR monitors river water quarterly for concentrations of alpha, nonvolatile beta, and tritium at seven locations from Augusta, Georgia, to the Highway 301 bridge. GDNR data for tritium in surface water are comparable with SRP results. GDNR has made special surveys along the Savannah River at additional sampling locations. Tritium levels in river water were comparable to levels found at SRP.

Savannah River and onsite stream floodplain sediment

Since 1975, sediment samples have been collected in floodplain areas of the Savannah River at six locations above, adjacent to, and below the Savannah River Plant. Sediment sample collection points were selected at strategic locations to obtain an estimate of the maximum accumulation of radioactivity in the river bed. Following rigorous analyses for various radionuclides, sediment results are useful in the determination of potential changes in radioactivity transport in the river.

GDNR analyzes river sediment samples annually at multiple river locations for gamma activity. These values were determined to be within the range of SRP data. Specific radionuclides are analyzed based on initial gamma results.

BF-3

Since 1977, sediment samples have been collected from onsite SRP stream floodplain areas. Samples are collected along these streams at multiple transects and composited for radioanalysis. These floodplain sediment data from onsite streams provide an annual accounting of sediment radioactivity from SRP sources, global fallout, and other sources.

Swamp

Comprehensive surveys were conducted annually in the Savannah River swamp between Steel Creek Landing and Little Hell Landing from 1974 to 1977. These surveys included soil, vegetation, animals, fish, and TLD-radiation measurements along 10 trails transecting the swamp. These annual surveys did not show any change in radiological conditions, and their frequency was reduced to once every 5 years, although annual TLD measurements were continued. A comprehensive survey was conducted in 1982, and another comprehensive survey will be conducted to determine any changes in radiological conditions during the first year after restart of L-Reactor operation.

Soil

Since 1973, soil samples have been collected at both the SRP boundary at strategic perimeter locations and off the site at two locations. Compositated sediment samples are analyzed for individual radionuclide dry-weight concentrations and for cumulative deposition of radioactivity by individual radionuclides. The two offsite locations, which are about 160 kilometers from the center of the plant, serve as control locations.

Additional terrestrial sediments are collected from eight onsite locations encompassing the Separations Areas; these sediments are analyzed for radionuclide concentrations and cumulative deposition, similar to the plant perimeter samples.

GDNr collects sediment samples in Georgia near the SRP on a quarterly basis. These samples are analyzed for gamma activity; they have been found to be within the range of SRP data.

BF-3

Ground water

Ground-water samples from a large number of monitoring wells are collected and analyzed for radioactivity content (Du Pont, 1979). Drinking-water supplies at 23 onsite facilities and 14 surrounding towns are analyzed semiannually for alpha, nonvolatile beta, and tritium. The remaining samples of ground water are collected from wells installed in the vicinity of production and waste-management facilities. Monitoring-well samples from SRP production and waste-management facilities are also analyzed for alpha, nonvolatile beta, and tritium.

SCDHEC monitors for concentrations of alpha, nonvolatile beta, and tritium in ground water from wells in six nearby communities and from additional wells around the Barnwell Nuclear Fuel Plant. GDNr monitors for the same parameters at 10 Georgia locations. Both State programs are on a quarterly frequency.

BF-3

Vegetation and food

Grass samples (generally Bermuda) are collected routinely during the growing season at all air monitoring locations. Samples are analyzed individually for alpha, nonvolatile beta, and tritium, and are composited monthly for specific gamma analyses. Other vegetation samples are collected and analyzed as part of the general survey program as well as when an unusual release of radioactivity is suspected.

BF-3

SCDHEC collects vegetation samples annually at six locations around the Chem-Nuclear Services, Inc., facility and measures them for gamma activity. GDNR collected quarterly vegetation samples at eight locations during the 1980-1982 period; these samples were measured for gamma activity and specific radionuclide analyses.

Milk is sampled routinely at six local dairies within a 40-kilometer radius of Savannah River Plant, and samples are also obtained from a major distributor (from milk produced in the area and sold by the distributor). These samples are analyzed for tritium, iodine-131, cesium-137, and strontium-90. Over 60 samples of farm produce representing the food categories of leafy vegetables, fruit, grain, poultry, eggs, and meat are collected at 14 locations in the six counties surrounding Savannah River Plant. Six locations are near the SRP perimeter and eight at a distance of approximately 40 kilometers. With the exception of grains, all foods are prepared as though for human consumption and then are subjected to radioanalysis.

BF-3

SCDHEC and GDNR each monitor milk samples from at least three local dairies in the area surrounding SRP. SCDHEC monitors total strontium, iodine-131, cesium-137, and tritium on a quarterly frequency. GDNR monitors strontium-89, strontium-90, cesium-137, and tritium on a monthly frequency. The range of strontium-90 and cesium-137 milk concentrations reported by SCDHEC and SRP is consistent for the 1979-1982 period, although the sampling locations were different. GDNR data for tritium in milk samples from dairies near SRP were comparable with SRP results during the 1980-1982 period.

Fish are trapped routinely in the Savannah River upstream, adjacent to, and downstream of Savannah River Plant for radioanalysis. Fish from the river are also supplied for analysis by the Georgia Department of Natural Resources each year. Crabs and oysters from the Savannah River near the seacoast are analyzed for gamma emitters, including cesium-137, and for strontium-90.

Savannah River Plant conducts annual hunts for controlling onsite deer and hog populations. All deer and hogs are monitored for cesium-137 before being released to the hunters for consumption.

Drinking water

Communities near Savannah River Plant get drinking water from deep wells or surface streams. Public water supplies from 14 surrounding towns are sampled and analyzed semiannually.

Two water-treatment plants downstream from Savannah River Plant supply treated Savannah River water to customers in Beaufort and Jasper Counties in South Carolina, and Port Wentworth, Georgia. The Cherokee Hill Water Treatment Plant at Port Wentworth (Savannah) has been treating Savannah River water during the entire period of operation of Savannah River Plant. The Beaufort-Jasper Water Treatment Plant near Hardeeville, South Carolina, has been in operation since January 1965. The Beaufort-Jasper plant serves a consumer population of approximately 50,000. Treated water from the Port Wentworth, Georgia, plant is used primarily for industrial and manufacturing purposes in an industrial complex near Savannah, Georgia. The Port Wentworth Water Treatment Plant has an effective consumer population of about 20,000. Samples of raw and finished

water at both these plants were collected daily and composited for monthly alpha, nonvolatile beta, tritium, and cesium-137 analyses.

SCDHEC performs independent tritium and nonvolatile beta analyses from water samples at the Beaufort-Jasper treatment facility. These analyses are made at varying frequencies and are comparable with SRP data, although SCDHEC data do not match the sophisticated detection limits attainable by SRP. GDNR collects similar drinking-water samples from the water-treatment facility on a monthly basis and analyzes for alpha, nonvolatile beta, and tritium concentrations.

BF-3

6.1.2 Nonradiological monitoring programs

Monitoring the water quality and biota of the Savannah River has been continuing since 1951; SRP stream-water quality has been monitored since 1972.

Air

Wind data are measured at seven 61-meter meteorological towers on the SRP site and at the 366-meter WJBF-TV tower located off the site. Temperature data are also measured at the television tower and at one onsite station that records continuous temperature, maximum and minimum temperature, daily rainfall, relative humidity, and barometric pressure. Rainfall is monitored at the seven meteorological towers at Savannah River Plant.

Ambient air quality measurements at Savannah River Plant include determinations of sulphur dioxide (SO₂), nitrogen oxide (NO_x), ozone (O₃), and total suspended particulates. The SRP air monitoring program and instrumentation meet the requirements for a Prevention of Significant Deterioration monitoring program. In addition, South Carolina and Georgia each have implemented air sampling networks. There are eight sampling locations in the states' networks in the vicinity of Savannah River Plant. SCDHEC and GDNR both monitor for suspended particulates, sulfur dioxide (SO₂), and nitrogen dioxide (NO₂).

BF-3

Surface water

Savannah River water is collected monthly at two locations, above and below Savannah River Plant, and analyzed for 24 water-quality parameters. Fecal coliform in water is analyzed from the same locations weekly. A semiannual water sample from the river adjacent to Savannah River Plant is sent to the Georgia Department of Natural Resources for analyses of 14 water-quality parameters, including standard parameters, nutrients, major ions, and fecal coliform counts. GDNR completed additional monthly water-quality analyses at river pump-house locations in the early 1970s. Concentrations of 32 pesticides or herbicides and PCB are determined at these locations annually. Sediment samples from these locations are analyzed for PCB, herbicides, and pesticides.

BF-3

The Academy of Natural Sciences of Philadelphia (ANSP) makes quarterly water-quality surveys at five stations in the Savannah River. Every 5 years, or as a result of major changes in the physiography of the river, ANSP also makes comprehensive surveys of the biota and chemical water quality above, adjacent to, and below Savannah River Plant to ascertain effects of SRP operations.

The U.S. Geological Survey continuously monitors the temperature and flow of the Savannah River above and below Savannah River Plant and at the mouths of Beaver Dam, Four Mile Creek, and Steel Creek. Measurements of the extent of thermal plumes in the river at the mouths of these creeks are made quarterly.

Aquatic biota

The Limnology Department of ANSP, under contract to Du Pont, has been performing a continuing survey of aquatic organisms in the Savannah River upstream, adjacent to, and downstream from Savannah River Plant since 1951 (Matthews, 1982). Diatoms have been and continue to be collected biweekly. Prior to 1982, other algae, invertebrates, and fish were sampled approximately quarterly. In the spring and summer of 1982, ANSP personnel performed a comprehensive baseline study of algae and invertebrates in the mouth of Steel Creek and in the Savannah River just below Steel Creek in conjunction with plans to restart L-Reactor. Another identical study will be completed in 1983. Similar comprehensive studies are tentatively planned for 1984 and 1985.

TC Mercury from industrial sources above SRP was first detected in fish in 1971. Individual fish were analyzed in 1972 on a quarterly basis by species composites (bream, bass, and catfish). From 1973 through 1975, species composites were analyzed semiannually; from 1976 through 1982, river fish were again analyzed individually. Currently, fish traps are checked weekly at five locations above and below SRP for mercury determination. Mercury levels in fish in 1982 were determined to be essentially the same as those detected in recent years.

Ground water

The quality of the ground water underlying the SRP site is determined by a continuing program of sample collection and analysis for nonradioactive parameters and constituents. Drinking-water supplies from the Tuscaloosa aquifer are sampled and analyzed for content of inorganic ions, organic substances, and metals. Monitoring wells have been installed at both inactive and active waste-disposal sites to gather information about the fate of materials discarded at these sites (Du Pont, 1983b).

Water samples are collected quarterly from ground-water monitoring wells that surround the sanitary landfill site and are analyzed for a number of water-quality parameters. Additionally, water samples are collected and analyzed for trace metals and other drinking-water contaminants once a year. The South Carolina Department of Health and Environmental Control (SCDHEC) has revised monitoring requirements for the sanitary landfills. After four quarters of comprehensive analyses, only semiannual sample collection is needed, with analysis for indicator parameters.

6.1.3 Comprehensive cooling-water study

In July 1983, DOE initiated a 2-year program to determine the environmental effects of cooling-water intake and discharge of the SRP production reactors (C, K, L, and P) and coal-fired power plant operations. This study also draws on the results of ongoing environmental monitoring programs at Savannah River

Plant. The State of South Carolina, the State of Georgia, the U.S. Environmental Protection Agency (Region IV), the U.S. Fish and Wildlife Service (Region IV), and the U.S. Army Corps of Engineers (South Atlantic Division) are participating in this study. The study area includes Par Pond, the SRP onsite streams, the Savannah River swamp, and the Savannah River from Augusta, Georgia, downstream to the area of salt-water intrusion.

Topics to be addressed in the cooling-water study include (1) effects on water usage and quality, (2) wetland effects, (3) effects on fisheries, (4) effects on endangered species, and (5) radionuclide and heavy-metal remobilization, deposition, and effects. Details of these study areas are given below.

Water quality

Water quality studies will provide monitoring data for an assessment of the potential effects of present and proposed SRP activities on the quality of the water used for cooling at the SRP site. The significance of any effects SRP operations have on cooling water will be determined. The quality of water in the Savannah River above and below the SRP, onsite streams, the swamp adjacent to the SRP, and Par Pond will be evaluated.

TC

The assessment of thermal effects includes the description and interaction of thermal plumes in the Savannah River swamp along the Savannah River Plant and in the Savannah River from both SRP operations and other thermal effluent sources. These integrated studies are being conducted both upstream and downstream of the Savannah River Plant to facilitate comparisons of assessed values of wetlands, fish spawning, nursery areas, and water quality and to provide perspective concerning the significance of any SRP thermal impacts.

Effects on wetland

Wetlands studies are designed to provide ecological and environmental data for assessing the effects of the operation of the SRP reactors and the 400-D Area coal-fired powerhouse on the wetland ecosystems of the SRP site, including the swamp and onsite streams. The effects to be examined include changes in community structure and diversity, productivity, distribution, habitat use by various wildlife species, and historic changes in vegetation zones in the delta areas where the effluent streams enter the swamp. The comparison of thermally affected and nonthermally affected wetland areas will allow the evaluation of the consequences of releasing cooling water into the SRP streams and swamp system and the significance of those consequences.

TC

Effects on fisheries

Ongoing entrainment and impingement studies at the SRP intakes are being incorporated into this comprehensive study. The studies will assess the effect of the withdrawal of fish eggs and larvae and will provide impingement-loss estimates at the intakes. Loss estimates from entrainment and impingement will be related to the relative abundance of river fish populations to determine the effect of SRP operations on the Savannah River system. Current fisheries studies have been expanded to determine the potential spawning areas at approximately 16-kilometer intervals along the Savannah River and near the mouth of named tributaries that enter the Savannah River from Augusta downstream to the area of salt-water intrusion (River Mile 40). Relative abundance of fish eggs and

larvae will be compared to assess the importance of the area near Savannah River Plant as a spawning area relative to the Savannah River system.

Fisheries studies currently being conducted on the Savannah River in the vicinity of Savannah River Plant are being continued and expanded to assess the thermal effects on representative important fish species, including any endangered species. These studies will include (1) assessment of effects on migratory fish by thermal plumes; (2) thermal plume attraction/avoidance, including assessment of over-wintering impacts on growth, cold shock, maturation, and disease and parasitism; (3) effects on spawning and nursery grounds; and (4) seasonal plume habitat modification.

Effects on endangered species

Studies on the effects of heated effluents on endangered species, particularly the American alligator and wood stork and their associated habitat along study-area streams, the Savannah River, and adjacent land areas in the vicinity of Savannah River Plant are being conducted (see Section 6.2.5).

Radionuclide and heavy-metal transport

EJ-3 | The objective of this element of the study is to provide monitoring data that can be used to quantify and assess the significance of the release of radionuclides and heavy metals from SRP facilities via cooling water and the subsequent transport of these materials to Par Pond, the onsite stream/swamp areas, the Savannah River, and downriver water-treatment plant facilities. Measurements will be made to determine on-plant and off-plant deposition sites of radionuclides and heavy metals and to evaluate current and future remobilization from these areas. Extensive measurements for radioactivity in water at the Beaufort-Jasper and Port Wentworth water-treatment plants will be made to assess the health significance of releases from SRP operations.

6.1.4 Thermal mitigation study

FK-26 | DOE is conducting an evaluation of alternative cooling concepts to mitigate impacts of thermal discharges from the currently operating SRP reactors (C, K, and P). This assessment will include alternative cooling methods (i.e., cooling towers, ponds or lakes, precooled ponds, and spray canals), potential modifications of plant operations and protection of representative and important species. The study will also consider energy recovery systems such as cogeneration and the operation of a fish hatchery as means to mitigate possible thermal effects.

Information developed for each concept will include conceptual design data, capital and operating cost estimates, production loss estimates, effects on other SRP operations, construction schedules, NEPA compliance, and permit requirements. Cost-benefit procedures will be applied to each system to determine its relative value. Effects from current operations will be compared to information developed for alternative cooling concepts to determine if mitigative action is warranted and, if so, what action should be taken. The goals of the

study are to complete and submit the thermal mitigation studies to SCDHEC within 9 months of the signing of the consent order and to implement the recommended thermal mitigation alternative approved by SCDHEC under a schedule to be established by SCDHEC in a subsequent order. DOE will submit and actively support appropriate funding requests to accomplish any actions resulting from the comprehensive thermal studies.

FK-26

6.1.5 Epidemiological studies

Regional

Three separate health effects studies of cancer and infant death have been made in areas around Savannah River Plant and in counties using downstream river water (Sauer, 1975, 1976, 1979). These studies encompassed the period from 1949, before SRP startup, through 1976. A fourth study, currently in progress, will consolidate the three previous studies, fill in missing time periods, and update mortality rates through 1978, the most recent year for which mortality data were available from the National Center for Health Statistics. The studies concentrate on those types of cancer for which a proven causal relationship with radiation exposure has been demonstrated.

Occupational

The Occupational Epidemiology Section, Oak Ridge Associated Universities, and the Epidemiology Group, Los Alamos National Laboratory, are each conducting studies of SRP workers. Both the Oak Ridge morbidity and mortality studies of radiation workers and the Los Alamos health effects studies of plutonium workers are in the early data collection and validation phase. Because these are comprehensive studies, results will not be available for several years.

Future

The scope and results of ongoing epidemiological studies designed to assess any possible effects that SRP operations might have on human health were made available by DOE to a panel of experts, including participants from the Centers for Disease Control, the South Carolina Department of Health and Environmental Control, and the Division of Public Health of the Georgia Department of Human Resources. The panel of experts will determine if there is a need for additional epidemiological studies of SRP workers or the population around the Savannah River Plant. DOE will conduct public hearings on the panel's findings and initiate any required epidemiological study as a result of this process.

6.1.6 Ground-water protection

A draft "SRP Groundwater Protection Implementation Plan" was recently developed to examine strategies and schedules to implement mitigative actions required to protect the quality of the ground waters beneath SRP. In addition to the commitment for closing the M-Area seepage basin by April 1985, this site-wide plan considers other remedial actions, including discontinuing the use of seepage basins in F- and H-Areas and the use of the present SRP Burial Ground.

AJ-1,
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AJ-1,
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EN-42

Contingent on Congressional authorization and approval of a FY 1986 funding request, DOE plans to operate an effluent-treatment facility by October 1988 to process wastewater being discharged to the F- and H-Area seepage basins. The implementation of mitigative actions would be accomplished under DOE's hazardous waste management program; these actions would be compatible with the State of South Carolina hazardous waste management regulations.

The sitewide ground-water protection plan will be the subject of a separate NEPA review. Topics to be discussed in this review include the sitewide use of seepage basins, disposal pits, and the burial ground; remedial and mitigation measures; the decommissioning of currently operating facilities receiving hazardous wastes; occupational and offsite exposures; and effects of research and development activities. Appendix F contains additional details.

6.2 L-REACTOR MONITORING PROGRAMS

Many of the site-wide monitoring programs described in Section 6.1 provide information directly applicable to L-Reactor operation. Monitoring programs specifically related to L-Reactor will provide additional information on the disposition of effluents from L-Reactor. These programs are described below.

6.2.1 Nonradiological monitoring

In addition to the Savannah River measurements described in Section 6.1, the U.S. Geological Survey continuously monitors flow in Steel Creek at the Hattiesville site and temperature at the mouth of the creek. Following L-Reactor restart, the dimensions (surface area and cross section) of the thermal plume downstream from the mouth of Steel Creek will be measured quarterly by sampling along river transects. In addition, airborne thermal infrared scanner data will be analyzed to supplement the surface-area measurements.

Savannah River Plant collects water samples monthly from Steel Creek near Cypress Bridge (Du Pont, 1979). These samples are analyzed for 23 water-quality parameters. Additional water-quality monitoring will be conducted in accordance with the National Pollutant Discharge Elimination System permit for L-Area effluents. In February 1983, a comprehensive water-quality monitoring program that includes biweekly sampling of 26 parameters at 8 sites in Steel Creek and several sites above and below Steel Creek in the Savannah River was initiated. Special water-quality sampling, including total residual chlorine monitoring, is planned for the L-Reactor flow test to be conducted prior to the restart.

The existing SRP air quality monitoring programs (Du Pont, 1979, 1983a) are considered adequate to monitor nonradioactive air pollutants from L-Area.

6.2.2 Radiological monitoring

To supplement the existing SRP radiological-monitoring program described in Section 6.1, thermoluminescent dosimeters (TLDs) were installed at the four corners of L-Area in 1981 and are changed every 3 months to measure the accumulated dose. Paddlewheel continuous samplers are located in the L-Reactor cooling-water effluent canal, above L-Reactor on Steel Creek, and below L-Reactor on Steel Creek near Hattieville. Representative composite samples are analyzed weekly for radionuclides.

See also Section 2.1.3 for a discussion of in-plant process and effluent monitoring.

6.2.3 Ground-water monitoring

The quality of ground water at the L-Reactor site will be monitored by four wells located around the L-Area low-level radioactive seepage basin. Water will be collected from these wells quarterly and analyzed for alpha, nonvolatile beta, and tritium as well as several water-quality parameters.

6.2.4 Radiocesium monitoring

DOE has established a comprehensive environmental monitoring program to determine the transport of cesium-137 from Savannah River Plant resulting from the startup of L-Reactor. The program consists of analyses of water samples from Steel Creek, Savannah River, and the downstream water supplies (Beaufort-Jasper, South Carolina, and Port Wentworth, Georgia). Cesium-137 is not detectable in upstream or downstream river samples by routine monitoring techniques that have minimum detection limits of about 1.0 picocurie per liter. The routine monitoring program has been in effect at the site for about 30 years. A special monitoring for cesium-137 and total suspended solids will be conducted for a minimum of 1 year following L-Reactor startup and operation.

Aerial radiological surveys of Savannah River Plant and surrounding areas were conducted by the DOE Remote Sensing Laboratory, operated by EG&G, Las Vegas, in 1974, 1979, 1982, and 1983. These surveys will continue after L-Reactor startup.

Special monitoring programs for cesium-137 and total suspended solids will be conducted during cooling-water cold-flow tests. These data will be used to evaluate releases from individual tests and to verify transport models used to estimate the remobilization of cesium during reactor operations. During tests of limited flow, weekly composite water samples will be taken at the mouth of Steel Creek and at Cypress Bridge. For the full-flow tests, daily composite water samples will be taken at multiple points along Steel Creek. Additional special sampling will be made to determine the amount of cesium-137 transported in the suspended sediments.

The drinking-water monitoring program will include measurements of both cesium-137 concentration in the Savannah River above and below Savannah River

Plant and water-treatment plant raw and finished water above and below Savannah River Plant. The Savannah River estuary and the Savannah River, as well as water-treatment sludge ponds, will be studied to determine potential cesium-137 buildup in sediments. These measurements started in March 1983, and will continue for at least 1 year following L-Reactor startup.

Measurements in the Savannah River will provide a material balance of the total cesium-137 discharged to and transported by the river. Measurements of raw river water and finished drinking water will provide cesium-137 concentrations to verify earlier estimates made for transport. Measurements of cesium-137 in the estuary will be compared to earlier measurements to determine long-term trends.

6.2.5 Ecology

Ecological monitoring plans following L-Reactor restart will emphasize changes in the status of Representative and Important Species (RIS) populations in the Steel Creek ecosystem. Vegetation studies will test for shifts in mortality, biomass, and species distributions in the delta and swamp regions; studies of changes in aquatic community structure will emphasize the lower regions of Steel Creek. Changes in patterns of utilization by selected resident avifauna will be examined with respect to alterations of preferred foraging and nesting areas. Monitoring studies will test for changes in the relative abundance of selected species of many amphibian and reptile species compared with the preoperational period.

Wetlands

The wetlands area affected and the delta growth rate will be monitored with both ground surveys and remote sensing. The ground surveys will be directed toward measuring the extent of effects on selected RIS. Remote sensing will be used to evaluate changes in vegetation patterns over larger survey areas and to estimate delta growth rates.

American alligator

Radiotelemetric studies have been conducted on adult male and female alligators in the Steel Creek corridor and delta since 1980 to evaluate their behavior and movements. Consultation with the U.S. Fish and Wildlife Service in the fall of 1982 outlined several steps to mitigate potential effects of L-Reactor startup on the Steel Creek alligator population.

The Steel Creek corridor will continue to be monitored to assess effects on the alligator population. Radiotelemetric studies, which have already been initiated with adult alligators, will continue at least through the winter following L-Reactor restart to determine the response of the Steel Creek alligator population to the startup.

AP-6, Earlier studies were based on L-Reactor restart with the direct discharge
AY-2, alternative. Because the preferred cooling-water alternative is now the 1000-
BA-6, acre lake, DOE has reinitiated consultations with FWS and has transmitted the
CV-1 most recent information on impact projections (Sires, 1984a).

Wood stork

The wood stork is listed as endangered by the U.S. Fish and Wildlife Service. Aerial surveys of the Savannah River swamp were conducted weekly from July 1981 to March 1982 and at irregular intervals from April to September 1982. Aerial surveys of the Birdsville rookery near Millen, Georgia, were conducted at irregular intervals from March to June 1982. Ground observations in the Steel Creek area have also been made (Appendix C). The field studies on the species have been expanded for summer 1983. Aerial and ground surveys will define the use of the SRP swamp system and any nearby rookeries, including the Birdsville rookery. In addition, use of other feeding areas by the Birdsville wood stork population will be evaluated. Previous survey information, along with these expanded studies, will be used to support consultation with the U.S. Fish and Wildlife Service on this species.

DOE has prepared a Biological Assessment for FWS review and use in formulating its Biological Opinion (Sires, 1984b). DOE is continuing to conduct studies and will continue to apprise FWS of the results.

AP-6,
AY-2,
BA-6,
CV-1

Shortnose sturgeon

Sturgeon larvae were identified in samples taken near the SRP pumphouses at the Savannah River during the 1982-1983 biological measurements program. A few of these were determined to be the federally endangered shortnose sturgeon (Appendix C). A biological assessment and consultation process with the National Marine Fisheries Service (NMFS) has been completed for this species. The NMFS has concurred with the DOE determination that the population of the shortnose sturgeon in the Savannah River would not be jeopardized (Oravetz, 1983).

AP-6,
AY-2,
BA-6,
CV-1

6.2.6 Archeology

Five archeological sites have been identified that could be affected by L-Reactor restart (see Section 3.1.3). Each of the five sites will be monitored on a monthly basis during the first 2 years of the L-Reactor operation to determine whether erosion occurs. If no erosion is evident at the end of the 2-year monitoring period, then the sites should be considered sufficiently protected to assure preservation.

Active erosion protection will be undertaken in the event that adverse erosion threatens the integrity of any of the sites. If erosion barriers are ineffective, recovery and documentation of the archeological data would be carried out.

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BF-3 | GDNR (Georgia Department of Natural Resources), 1983. Environmental Radiological Surveillance Report, Summer 1980-Summer 1982, Environmental Protection Division.

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BA-6, | enclosed biological assessment to Warren J. Parker, Field Supervisor -
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7 FEDERAL AND STATE ENVIRONMENTAL REQUIREMENTS

This chapter summarizes the Federal and State of South Carolina requirements that are applicable to the resumption of L-Reactor operations. Table 7-1 lists the permits and other environmental approvals needed for L-Reactor to resume operation. The requirements related to the cooling-water discharge reference case (direct discharge) and the preferred cooling-water alternative (the 1000-acre lake) are listed in Table 7-1; requirements corresponding to other cooling-water discharge alternatives are discussed in Section 4.4.2. To ensure that the preferred cooling-water alternative is a viable option for the decision-maker consistent with the restart of L-Reactor as soon as practicable, the Department prepared and filed dredge and fill (404) and NPDES permit applications with the U.S. Army Corps of Engineers and the South Carolina Department of Health and Environmental Control (SCDHEC), respectively, before the completion of this Final EIS. The requirements emphasize air quality, water quality, the disposal of solid and hazardous wastes, the protection of critical wildlife habitats, and the preservation of cultural resources.

TC

In addition to securing these permits and complying with applicable standards, as would be required for any similar large industrial facility, the Department of Energy (DOE), as a Federal agency, is also required to comply with a number of separate environmental requirements, such as the National Environmental Policy Act and wetlands/floodplains review requirements. DOE has established its own orders and regulations to assure the environmental, health, and safety protection of its facilities (Section 7.7).

National Environmental Policy Act of 1969, as amended (NEPA) (42 USC 4321 et seq.)

The National Environmental Policy Act of 1969, as amended, requires "all agencies of the Federal Government" to prepare a detailed statement on the environmental effects of proposed "major Federal actions significantly affecting the quality of the human environment." Signed by President Reagan on July 14, 1983, the Energy and Water Development Appropriations Act of 1984 directed the Department of Energy to prepare an environmental impact statement (EIS) on L-Reactor on an "expedited" basis. On July 15, the Federal District Court of Washington, D.C., ruling on a lawsuit filed in November 1982, directed the Department of Energy to prepare an EIS on the proposed restart of the L-Reactor as soon as possible. This environmental impact statement has been prepared in accordance with the Council on Environmental Quality Regulations on Implementing National Environmental Policy Act (40 CFR 1500-1508) and DOE Guidelines for Compliance with the National Environmental Policy Act (45 FR 20694, March 28, 1980).

TC

Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.)

DOE is required to comply with radiation guidance pursuant to the Atomic Energy Act of 1954, as amended (42 USC 2021(h)). In accordance with the Energy Reorganization Act of 1974, DOE defense-related operations are not subject to the regulations of the Nuclear Regulatory Commission. DOE has issued extensive standards and requirements to ensure safe operations.

Table 7-1. Required regulatory permits and notifications

Activity/facility	Requirement(s)	Agency	Status
Water			
Process and sanitary-sewer outfalls	NPDES permit Construction permit	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Discharges permitted Construction permitted
Domestic water supply system	Permit to construct ground-water wells, treatment and distribution systems	South Carolina Department of Health and Environmental Control, Water Supply Division	Domestic water-supply system construction permitted
Cooling-water discharge -	316(a) (thermal impact) study	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	See Appendix L
Cooling-water discharge, preferred alternative (1000-acre lake)	NPDES permit	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Pending completion of FEIS
	Dredge and fill permit (Section 404)	U.S. Army Corps of Engineers	Pending completion of FEIS
	Certification (Section 401)	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Requested by COE as part of the dredge and fill permit process
Oil storage	Spill prevention, control and counter-measure plan	EPA/South Carolina Department of Health and Environmental Control	To be included in overall plan for SRP

TC

Table 7-1. Required regulatory permits and notifications (continued)

Activity/facility	Requirement(s)	Agency	Status
Air			
L-Area emergency diesel generators	Operation permits	South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control	Permitted
F-, H, and M-Area process facilities	Operation permit amendments	South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control	Application under review
K-Area powerhouse	Operation permit	South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control	New permit not required
Endangered species			
Endangered species	Consultation/biological assessment	U.S. Fish and Wildlife Service and National Marine Fisheries Service	Consultations with FWS in process; consultations with NMFS completed
Fish and Wildlife Coordination Act	Consultation/consideration of fish and wildlife resources	U.S. Fish and Wildlife Service	Consultations with FWS in progress
Migratory Bird Treaty Act	Consultation with FWS and development of mitigation plan	U.S. Fish and Wildlife Service	Consultation with FWS in progress
Anadromous Fish Conservation Act	Consultation with FWS and development of mitigation plan	U.S. Fish and Wildlife Service	Consultation with FWS in progress

Table 7-1. Required regulatory permits and notifications (continued)

Activity/facility	Requirement(s)	Agency	Status
Historic preservation	Archeological survey and assessment	South Carolina Historic Preservation Officer	1000-acre lake will require new survey compliance, etc.
Floodplain/wetlands	Assessment and determination	U.S. Department of Energy	To be updated based on FEIS
Hazardous wastes	Resource Conservation and Recovery Act Requirements	U.S. Department of Energy/ South Carolina Department of Health and Environmental Control/U.S. Environmental Protection Agency	RCRA Program Management Plan in place

TC

Executive Order 12088 (October 13, 1978)

This Executive Order requires Federal agencies to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the following Federal laws:

1. Toxic Substances Control Act (15 USC 2601 et seq.)
2. Federal Water Pollution Control Act (33 USC 1251 et seq.)
3. Public Health Service Act, as amended by the Safe Drinking Water Act (42 USC 300 (f) et seq.)
4. Clean Air Act (42 USC 7401 et seq.)
5. Noise Control Act (42 USC 4901 et seq.)
6. Solid Waste Disposal Act (42 USC 6901 et seq.), also referred to as the Resource Conservation and Recovery Act.

Historic Preservation Act

No permits, certifications, or approvals related to historic preservation are required; however, DOE must provide the Advisory Council on Historic Preservation an opportunity for comment and consultation, as required by the Historic Preservation Act of 1966 (16 USC 470(f) et seq.). Section 106 of this Act requires any agency with jurisdiction over a Federal "undertaking" to provide the Council an opportunity to comment on the effect the activity might have on properties included in, or eligible for nomination to, the National Register of Historic Places.

In addition, Executive Order 11593 requires Federal agencies to locate, inventory, and nominate properties under their jurisdiction or control to the National Register of Historic Places if those properties qualify. Until this process is complete, the agency must provide the Advisory Council an opportunity to comment on the possible impacts of the proposed activities on the properties.

Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) (May 24, 1977)

These Executive Orders require governmental agencies to avoid to the extent practicable any short- and long-term adverse impacts on floodplains and wetlands wherever there is a practicable alternative. The DOE has issued regulations 10 CFR Part 1022, which establish DOE procedures for compliance with these Executive Orders.

Clean Air Act (42 USC 7401 et seq.) as amended by the Clean Air Act Amendments of 1977 (PL 95-95)

Section 118 requires that each Federal agency, such as DOE, having jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with "all Federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution. Authority for regulation of air emissions has been delegated by the U.S. Environmental Protection

Agency (EPA) to the South Carolina Department of Health and Environmental Control (SCDHEC), Bureau of Air Quality Control. The EPA has also proposed draft regulations for airborne radiation limits (40 CFR 61; 48 FR 15076).

Federal Water Pollution Control Act of 1972 [Section 316(a)]

TC Section 316(a) of the Federal Water Pollution Control Act of 1972 (PL 92-500) authorizes the Environmental Protection Agency Regional Administrator to set alternative effluent limitations on the thermal component of discharges if the owner/operator (Department of Energy) demonstrates to the satisfaction of the Regional Administrator that the proposed effluent limitations are "more stringent than necessary to assure the protection and propagation of a balanced, indigenous population of fish, shellfish and wildlife in or on a body of water into which the discharge is to be made." Such a demonstration will be made to the South Carolina Department of Health and Environmental Control, which has received the NPDES authority and is the decisionmaker, with program overview by EPA (Section 402 of PL 92-500). The owner/operator must demonstrate, for the cooling-water alternative to be implemented, that the critical functions of a particular trophic level are maintained in the water body as they existed before the introduction of heat and that the impact caused by the heated effluent will not result in appreciable harm to the balanced, indigenous community. Such a demonstration includes scientific evidence that a balanced biological community will be maintained; there will be no adverse impacts to threatened and endangered species; no unique or rare habitats will be destroyed; a zone of passage for representative, important species will be provided; and receiving water temperatures outside any (State-established) mixing zone will not exceed the upper temperature limits for survival, growth, and reproduction of any representative, important species occurring in the receiving water. DOE will comply with this law by conducting a 316(a) demonstration in accordance with negotiations with SCDHEC to assure that its proposed cooling-water alternative will meet the necessary thermal limitations for protection of a balanced biological community.

Federal Water Pollution Control Act (Section 404), as amended by the Clean Water Act of 1977 (33 USC 1251 et seq.); River and Harbors Act of 1899

TC The Federal Water Pollution Control and Clean Water Acts require all branches of the Federal government engaged in any activity that might result in a discharge or runoff of pollutants to comply with Federal, state, interstate, and local requirements. Authority for implementation of these requirements has been given to the U.S. Army Corps of Engineers (COE) for dredge and fill permits (404 permits) and SCDHEC has been delegated authority by EPA to regulate wastewater discharges (NPDES permits). Individual (case-by-case) permits issued by the COE under Section 404 of the Clean Water Act are also reviewed by EPA (40 CFR 230). Dredge and fill activities in headwaters of creeks where the natural flow is 0.142 cubic meter per second or less are covered under a "nationwide" permit issued by COE.

TC The River and Harbor Act of 1899 prohibits dredging, construction, or other work in or affecting navigable waters of the United States, except in compliance with Sections 9 and 10 of the Act. The COE has been empowered to issue permits specifying acceptable activities in navigable waters (33 CFR 320.4, 321, 322, and 325).

Federal Water Pollution Control Act (Section 401), as amended by the Clean Water Act of 1977

The public notice of the 404 application includes a paragraph that constitutes a request by the COE on behalf of DOE for certification by SCDHEC in accordance with Section 401 of the Clean Water Act. Section 401 requires certification from SCDHEC that construction and operation-related discharges into navigable waters will comply with the applicable effluent limitations and water-quality standards of the Clean Water Act. This certification is a prerequisite for the 404 permit.

TC

Resource Conservation and Recovery Act (RCRA) of 1976 (42 USC 6901 et seq.)

This Act governs the generation, management, transportation, and disposal of solid and hazardous wastes. Currently, DOE is implementing Resource Conservation and Recovery Act (RCRA) requirements at the Savannah River Plant (SRP) pursuant to DOE Order 5480.2, "Hazardous and Radioactive Mixed Waste Management," issued on December 13, 1982. The SRP hazardous-waste management program meets the technical requirements of the EPA hazardous-waste regulations (40 CFR 260-265) and is compatible with SCDHEC requirements.

Since RCRA's enactment in 1976, DOE and one of its predecessors, the Energy Research and Development Administration, have taken the position that the regulatory scheme established by RCRA (including state permitting) does not supplant the regulatory scheme under the Atomic Energy Act that governs these facilities. This position is based on Section 1006(a) of RCRA, 42 U.S.C. 6905(a), that states that RCRA does not apply to "any activity or substance" that is "subject to" the Atomic Energy Act except to the extent that such application is not inconsistent with the requirements of the Atomic Energy Act. This position was communicated in writing to EPA in 1980; in 1982, EPA acquiesced in that view.

On June 22, 1983, the then Acting General Counsel of EPA disagreed with DOE's previously expressed views on the application of RCRA to these facilities. Although that analysis did not consider state permitting of Federal facilities generally authorized by RCRA, EPA seems to have taken the position that these facilities are subject to state permitting under RCRA, and therefore, their continued operation is dependent on permission granted by state officials or the annual facility-specific exemption authority provided to the President by Section 6001 of RCRA, 42 U.S.C. 6961.

TC

On February 22, 1984, DOE and EPA signed a Memorandum of Understanding (MOU) for hazardous waste and radioactive mixed waste. This MOU establishes a management program for such waste that is comparable to the design and performance criteria, other technical requirements, and recordkeeping and recording requirements of the regulations (40 CFR 260-266 and 270) that EPA has adopted to implement the Resource Conservation and Recovery Act. The MOU covers the generation, transportation, treatment, storage, and disposal of hazardous waste and radioactive mixed waste at SRP and other DOE facilities operated under the Atomic Energy Act, but does not address responsibilities for implementing the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). However, the MOU does address coordination with State and community relations concerning hazardous waste and radioactive mixed waste.

TC A lawsuit was filed alleging noncompliance with RCRA by one of DOE's Atomic Energy Act (AEA) facilities [Legal Environmental Assistance Foundation, Inc. v. Hodel, C. A. No. 3-83-562 (E. D. Tenn., filed September 20, 1983)]. On April 13, 1984, the District Court decided that DOE AEA facilities are subject to Federal and State permitting requirements under RCRA with respect to the treatment, storage, and disposal of hazardous waste covered by RCRA. As of May 1, 1984, the Solicitor General of the United States had not decided whether to appeal the adverse decision. Should no appeal be taken, DOE will apply the rule of this case to all its facilities. In that event, the Department intends to handle chemical waste determined to be hazardous under the requirements of RCRA in a manner consistent with the court decision. Radioactive mixed waste and other wastes not subject to the requirements of RCRA will continue to be handled in accordance with the MOU.

Noise Control Act of 1972 (42 USC 4901 et seq.)

Section 4 of this Act directs all Federal agencies "to the fullest extent within their authority" to carry out programs within their jurisdiction in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health or welfare. The DOE will comply with such requirements to the fullest extent possible.

Endangered Species Act of 1973 (16 USC 1531 et seq.)

The Endangered Species Act of 1973, as amended, is intended to prevent the further decline of endangered and threatened species and to bring about the restoration of these species and their habitats. The Act, which is jointly administered by the Departments of Commerce and Interior, does not require a permit, certification, license, or other formal approval. Section 7 does, however, require consultation to determine whether endangered and threatened species are known to have critical habitats on or in the vicinity of the site. DOE will comply with this law by taking all necessary precautions to ensure that its proposed action will not jeopardize the continued existence of any threatened or endangered species and/or their critical habitats.

Fish and Wildlife Coordination Act (16 USC 661 et seq.)

TC The Fish and Wildlife Coordination Act requires that equal consideration be given to the conservation of fish and wildlife resources during the development of a water-related project. Specifically, the Act requires that consultation be carried out with the Fish and Wildlife Service and appropriate state wildlife agencies with a view to the conservation of wildlife resources by preventing loss of and damage to such resources and by providing for the development and improvement thereof in connection with the project. DOE is required to give full consideration to the Habitat Evaluation Procedures report and recommendations of the Secretary of the Interior and the State agency, and the project plan shall include such justifiable means and measures for wildlife purposes as the reporting agency finds should be adopted to obtain maximum overall project benefits. No permit is required by this Act. However, the Department of Energy, subsequent to its consultations with the FWS, will consider the mitigation of impacts to fish and wildlife resources in accordance with the FWS Mitigation Policy (USDOI, 1981).

Migratory Bird Treaty Act (16 USC 703-712)

The Migratory Bird Treaty Act was enacted primarily to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. It regulates the harvest of migratory birds by specifying the mode of harvest, hunting seasons, bag limits, etc. The Act stipulates that it is unlawful at any time, by any means or in any manner to "kill...any migratory bird." Thus, avian mortality attributable to SRP operations (e.g., from chemical pollutants in seepage basins) would be unlawful under the provisions of this Act. Although no permit for this project is required under the Act, the Department of Energy is required to consult with the U.S. Fish and Wildlife Service regarding impacts to migratory birds, and to evaluate ways to avoid or minimize these effects in accordance with the FWS Mitigation Policy (USDOl, 1981).

Anadromous Fish Conservation Act (16 USC 757a-f)

The principal purpose of the Anadromous Fish Conservation Act is to enhance the conservation and development of the anadromous fishery resources of the United States that are subject to depletion from water resource development. Its applicability to the SRP is that populations of anadromous fishes are to be sustained and their movements unobstructed by plant operations. Although there is no permit required by this Act, the Department of Energy is required to consult with the U.S. Fish and Wildlife Service regarding impacts to anadromous fishes, and to evaluate ways to avoid or minimize these effects in accordance with the FWS Mitigation Policy (USDOl, 1981). When an anadromous fish is also an endangered species, the National Marine Fisheries Service (U.S. Department of Commerce) would be involved through the Endangered Species Act.

Safe Drinking Water Act of 1974, as amended

The L-Reactor public drinking water system is in compliance with the mandates of the Safe Drinking Water Act. The system received approval for startup from SCDHEC, which administers and enforces the Safe Drinking Water Act in the State. SCDHEC administration and enforcement consists of permits to construct, preliminary site inspections, final construction inspections, monthly sampling collections, and regular operations and maintenance inspections. Injection wells are not now and have not in the past been used for the disposal of wastewater.

7.1 HISTORIC PRESERVATION

An archeological and historic survey of the Steel Creek terrace and floodplain system was completed in February 1981. The survey revealed five sites that were nominated to the National Register of Historic Places (i.e., important and worthy of preservation from any adverse effects). A monitoring plan has been developed and implemented to protect these sites (Section 6.2.6).

A draft of the archeological survey report, which was prepared by the University of South Carolina's Institute of Archeology and Anthropology for DOE, was submitted to the South Carolina State Historic Preservation Officer (SCHPO). SCHPO representatives conducted a site visit in March 1982. DOE

requested a concurrence in a determination of no adverse effect on the five sites from the Keeper of the National Register of Historic Places and the Advisory Council on Historic Preservation. The State Historic Preservation Officer concurred in July 1982 with DOE-SR (Savannah River Operations Office) that these sites will not be impacted by L-Reactor restart provided that the proper erosion monitoring program is adopted (see Section 3.1.3).

TC

DOE has initiated the reconsultation process with SHPO concerning the mitigation of any new sites of historic significance that might be inundated by the 1000-acre lake or discovered in additional surveys for the lake.

7.2 SOLID AND CHEMICAL WASTE DISPOSAL

L-Area restart activities have generated a variety of residuals defined as solid and chemical wastes under Federal and South Carolina law. Disposal will take place at Savannah River Plant. DOE has developed a RCRA Program Management Plan (Sires, 1984a) for nonradioactive solid and hazardous waste at Savannah River Plant based on EPA and SCDHEC regulations.

Rubble materials are considered nonburnable wastes. Broken concrete asphalt and other construction debris have been buried in a rubble pit near L-Area. Notification and inspection of the SRP rubble pits have been completed. The use of rubble pits was discontinued on August 12, 1983.

The SRP sanitary landfill is designed and operated according to SCDHEC guidelines for the purpose of receiving domestic waste from SRP construction and operational activities. The sanitary landfill site was recently expanded from 10 acres to 32 acres, which will easily accommodate additional waste from L-Area.

Domestic sanitary sewage sludge is disposed of in a lagoon in the Central Shops area, consistent with SCDHEC guidelines.

7.3 ENDANGERED SPECIES

AP-6,
AY-2,
BA-6,
CV-1

The Endangered Species Act requires Federal agencies to ensure that none of their actions jeopardizes the continued existence of endangered or threatened species (or those that are proposed as such) or result in the destruction or adverse modification of designated critical habitat for such species. Federal agencies are required to consult with the U.S. Fish and Wildlife Service (FWS) and/or the National Marine Fisheries Service (NMFS) regarding the implementation of a proposed action. If FWS or NMFS indicates that an endangered or threatened species (or one that is proposed as such) or critical habitat could be present in the area of the proposed action, a biological assessment must be prepared. This assessment is used as a basis for evaluating the effects on Federally protected species through the formal consultation process.

The following sections summarize the status of the consultation process with the FWS and NMFS for four endangered species that would be affected by the direct discharge of cooling-water effluent into Steel Creek. Implementation of another cooling system (e.g., the preferred alternative) would require the reinitiation of the consultation process.

AP-6,
AY-2,
BA-6,
CV-1

7.3.1 American alligator

Formal consultation on the American alligator was held under the Endangered Species Act in September 1982 with representatives of DOE-SR, Du Pont, NUS Corporation, the Savannah River Ecology Laboratory (SREL), and the U.S. Fish and Wildlife Service (FWS). A Biological Opinion was received from the FWS in which FWS judged that protection of the lagoons at SRP Road A should provide sufficient mitigation for the American alligator potentially impacted by L-Reactor restart with the direct discharge alternative. Protection of these lagoons has been completed. Since the preferred cooling-water alternative is now the 1000-acre lake, DOE has reinitiated consultations with FWS. DOE has transmitted the most recent information on impact projections for this species (Sires, 1984b) to the FWS. DOE is awaiting a decision on its conclusion that the impacts resulting from the delayed restart of L-Reactor will not jeopardize the continued existence of this species.

AP-6,
AY-2,
BA-6,
CV-1

7.3.2 Red-cockaded woodpecker

The FWS has determined that the red-cockaded woodpecker will be unaffected by L-Area operations.

7.3.3 Shortnose sturgeon

Sturgeon larvae were identified in water samples taken near the SRP pumphouses at the Savannah River in 1982 and 1983. A few of these were determined to be the federally endangered shortnose sturgeon. A biological assessment and consultation process with the National Marine Fisheries Service (NMFS) has been completed for this species. NMFS has concurred with DOE determination that the population of the shortnose sturgeon in the Savannah River would not be jeopardized (Oravetz, 1983).

AP-6,
AY-2,
BA-6,
CV-1

7.3.4 Wood stork

The endangered wood stork forages at the Savannah River Plant, but does not breed on the site. The feeding individuals have been observed to be from the Birdsville Rookery some 50 kilometers away. DOE initiated informal consultation with FWS in July 1983 and in March 1984. DOE has prepared a Biological Assessment for FWS review and use in formulating its Biological Opinion (Sires, 1984c). DOE is continuing to conduct studies and apprise FWS of the results of continuing studies.

AP-6,
AY-2,
BA-6,
CV-1

7.4 WILDLIFE AND FISHERIES

TC Three regulations afford protection to wildlife and fisheries resources; they are the Fish and Wildlife Coordination Act, the Migratory Bird Treaty Act, and the Anadromous Fisheries Conservation Act. None of these acts requires the application or acquisition of a permit. Each act, however, requires that the Department of Energy consult with the U.S. Fish and Wildlife Service about impacts to fish and wildlife. Furthermore, DOE and FWS will undertake a cooperative effort that will mitigate impacts to fish and wildlife resources in accordance with the FWS Mitigation Policy. Consultations are currently underway with the FWS to ensure that DOE will comply fully with these three acts.

The Department of Energy is working with the Department of the Interior to perform the Habitat Evaluation Procedure (HEP). The HEP will identify the value of habitat to be gained or lost with the implementation of the preferred cooling-water mitigation alternative for use in assessing further mitigation. DOE will implement additional mitigative measures that might be identified through the HEP process. If required, DOE will request Congressional authorization and appropriation for the additional mitigation measures.

7.5 WATER QUALITY

Section 402 of the Clean Water Act, as amended, is the basis for controlling "point source" discharges of pollutants into navigable waters of the United States through the National Pollutant Discharge Elimination System (NPDES); this system is administered by the EPA, which has delegated NPDES permitting authority in South Carolina to the State of South Carolina. DOE applied to the State in 1981 for renewal and consolidation of its original NPDES permits. All L-Area outfalls with the potential for future use were included in the NPDES permit renewal application. Between 1981 and 1983, negotiations between SCDHEC and DOE were held to resolve issues related to the L-Reactor NPDES permit.

On December 15, 1983, SCDHEC announced its determination to issue an NPDES permit to the DOE for Savannah River Plant effective January 1, 1984. Based on this permit and a mutually agreed upon consent order, all discharges except thermal discharge from L-Reactor would be permitted. Thermal discharges from the three operating SRP reactors (C, K, and P) would be permitted provided that DOE would:

- TC
1. Complete a comprehensive study of the thermal effects of all operations at Savannah River Plant.
 2. Complete and submit thermal mitigation studies to SCDHEC within nine (9) months of signing of the consent order.
 3. Implement the recommended thermal mitigation alternative approved by SCDHEC under a schedule to be established by SCDHEC in a subsequent order.
 4. Submit and actively support appropriate funding requests to accomplish any actions resulting from the thermal studies.

All L-Area non-reactor-cooling-water effluent discharges are permitted pursuant to the December 15, 1983, announcement, including the discharge of sanitary wastewater and various nonprocess cooling waters from the control building, pumphouse, offices, and the security building.

Since August 1982, SCDHEC has considered SRP onsite streams and ponds to be Class B waters of the State, and not as receptors of industrial cooling water. This interpretation would limit the temperature of thermal effluents from L-Reactor as follows [SCDHEC, 1981; Section C.(7)].

- Discharges to an onsite stream - The temperature of the discharge "shall not exceed a maximum temperature of 90°F (32.2°C) at any time nor shall a maximum temperature rise above temperatures existing under natural conditions exceed 5°F (2.8°C) as a result of the discharge of heated liquids unless an appropriate temperature criteria or mixing zone, as provided below, has been established. The water temperature at the inside boundary of the mixing zone shall not be more than 18°F (10°C) greater than that of water unaffected by the heated discharge. The appropriate temperature criteria or the size of the mixing zone shall be determined on an individual project basis and shall be based on biological, chemical, engineering and physical considerations. Any such determination shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on a body of water to which the heated discharge is made and shall allow passage of aquatic organisms."
- Discharge to a lake or reservoir - The temperature of the discharge "shall not exceed a weekly average temperature of 90°F (32.2°C) after adequate mixing as a result of heated liquids, nor shall a weekly average temperature rise of more than 5°F (2.8°C) above temperatures existing under natural conditions be allowed as a result of the discharge of heated liquids unless an appropriate temperature criteria or mixing zone, as provided below, has been established. The water temperature at the inside boundary of the mixing zone shall not be more than 18°F (10°C) greater than that of water unaffected by the heated discharge. The appropriate temperature criteria or the size of the mixing zone shall be determined on an individual project basis and shall be based on biological, chemical, engineering and physical considerations. Any such determination shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on a body of water to which the heated discharge is made and shall allow passage of aquatic organisms."
- Case-by-case determinations - "Upon a case-by-case determination by the Department and in accordance with the Act, the Clean Water Act (P.L. 92-500, 95-217), and related regulations, the above temperature criteria may not apply to cooling water bodies with a primary purpose of providing a source and/or being a receptor of industrial cooling water."

As noted in Section C.(8) of SCDHEC (1981), the temperature standards for Class B waters of the State are applicable when the flow rate is equal to or greater than the minimum 7-day average flow rate that occurs with an average frequency of once in 10 years. However, the temperature of the discharge cannot

be so high that it interferes with water uses or is harmful to human, animal, plant, or aquatic life.

Section 4.4.2 describes alternative cooling-water systems for L-Reactor and indicates their ability to meet the Class B water-quality standards (discussed above). The preferred cooling-water alternative of the Department of Energy is to construct a 1000-acre lake before L-Reactor resumes operation, to redesign the reactor outfall, and to operate L-Reactor in a way that assures a balanced biological community in the lake (i.e., to maintain 32.2°C or less for about 50 percent of the lake). After L-Reactor is operating, DOE will conduct studies to determine the effectiveness of the cooling lake and to decide on the need for precooling devices to allow for greater operational flexibility. The preferred alternative, other alternative cooling-water systems, and other thermal mitigation measures have been the subject of ongoing discussions with SCDHEC. At the time of publication, discussions on these alternatives and mitigation methods and on the incorporation of L-Reactor thermal discharge into the overall SRP NPDES permit were continuing.

In early December 1983, DOE also initiated discussions with the COE regarding dredge and fill permits under Sections 9 and 10 of the River and Harbor Act and Section 404 of the Clean Water Act. DOE has submitted its 404 application for the 1000-acre lake, and the public notice describing the proposed construction has been issued. The public notice of the 404 application also includes a paragraph that constitutes a request by the COE on behalf of DOE for certification by SCDHEC in accordance with Section 401 of the Clean Water Act. Section 401 requires certification from SCDHEC that construction and operation-related discharges into the navigable waters will comply with the applicable effluent limitations and water quality standards of the Clean Water Act. This certification is a prerequisite for the 404 permit approval from the Corps of Engineers.

L-Area will contain two surface fuel-oil storage tanks with capacities of approximately 30,000 and 11,000 liters. Each tank has a spill containment structure around it. L-Area will be included in the Spill Prevention Containment and Control plans for the Savannah River Plant.

7.6 FLOODPLAIN/WETLANDS

DOE issued a floodplain/wetlands notice regarding the proposed reactivation of L-Reactor on July 14, 1982 (47 FR 30563). A floodplain/wetlands determination regarding no practical alternative was published in the Federal Register on August 23, 1982 (47 FR 36691-2). The floodplain/wetlands assessment has been updated (see Appendix I) and the floodplain/wetlands determination will be updated and/or modified after completion of the Final Environmental Impact Statement.

The Fish and Wildlife Service's mitigation policy for wetlands is stated in 46 FR 7644-7663. This policy establishes four resource categories to establish mitigation levels consistent with the fish and wildlife resources involved. The wetlands that would be impacted by the restart of L-Reactor are categorized under Resource Category 2 as habitat of "high value for evaluation species" and

are "scarce or becoming scarce." The mitigation goal under this policy requires that there be "no net loss of inkind habitat value."

FK-6

7.7 AIR QUALITY

The authority for the regulation of air emissions has been delegated by the EPA to the Bureau of Air Quality Control of the SCDHEC. The Bureau issues operating permits and performs Prevention of Significant Deterioration reviews. Because existing facilities will be used to supply steam and electric power to L-Reactor on a continuous basis, no new SCDHEC operating permits will be required for these facilities.

SCDHEC air pollution regulations require both construction and operating permits for emergency diesel generators that have greater than 150-kilowatt-rated capacity. L-Area will have three emergency diesel generators rated at more than 150 kilowatts; they have been on standby since L-Reactor operation was suspended in 1968. The permits necessary for their operation have been received from SCDHEC.

Modifications to the operating permits for increases in nitrous oxide emissions from the process facilities in F-, H-, and M-Area are currently under review by SCDHEC.

EPA has retained jurisdiction for the regulation of airborne radionuclides. The Savannah River Plant operates within the limits of the draft regulations currently proposed (48 FR 15076) and will remain in compliance after the restart of L-Reactor.

7.8 DEPARTMENT OF ENERGY HEALTH AND SAFETY ORDERS

DOE is responsible for assuring the health and safety of its own facilities and has established comprehensive health, safety, and environmental programs. These are contained in the following DOE Orders:

- DOE Order 5440.1B, "Implementation of National Environmental Policy Act," May 14, 1982.
- DOE Order 5480.1A, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," August 13, 1981.
 - Chapter I - Environmental Protection, Safety, and Health Protection Standards
 - Chapter II - Reserved
 - Chapter III - Safety Requirements for the Packaging of Fissile and Other Radioactive Materials

- Chapter IV - Reserved
 - Chapter V - Safety of Nuclear Facilities
 - Chapter VI - Safety of Department of Energy Owned Reactors
 - Chapter VII - Fire Protection
 - Chapter VIII - Contractor Occupational Medical Program
 - Chapter IX - Construction Safety and Health Program
 - Chapter X - Industrial Hygiene Program
 - Chapter XI - Requirements for Radiation Protection
 - Chapter XII - Prevention, Control, and Abatement of Environmental Pollution
 - Chapter XIII - Aviation Safety
- DOE Order 5484.2, "Unusual Occurrence Reporting System," August 13, 1981.
 - DOE Order 5483.1, "Occupational Safety and Health Program for a Government Owned Contractor Operated Facility," April 13, 1979.
 - DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements," February 24, 1981.
 - DOE Order 5480.2, "Hazardous and Radioactive Mixed Waste Management," December 13, 1982.
 - DOE Order 5481.1A, "Safety Analysis and Review System," August 13, 1981.
 - DOE Order 5482.1A, "Environmental Protection, Safety, and Health Protection Appraisal Program," August 13, 1981.
 - DOE Order 6430 (draft), "Department of Energy General Design Criteria Manual," June 10, 1981.

REFERENCES

- | | |
|--|---|
| <p>Oravetz, C. A., 1983. Letter dated November 1, 1983, to M. J. Sires, Assistant Manager, Health, Safety, and Environment, U.S. Department of Energy, Savannah River Plant, from C. A. Oravetz, Chief, Protected Species Branch, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (F/SERV 23:AM:CF).</p> | <p>AP-6,
AY-2,
BA-6,
CV-1</p> |
| <p>SCDHEC (South Carolina Department of Health and Environmental Control), 1981. <u>Water Classification Standards</u>, Columbia, South Carolina.</p> | |
| <p>Sires, M. J., 1984a. Letter dated January 10, 1984, to Goetz K. Oertel, Acting Manager, Savannah River Operations Office, from M. J. Sires, Assistant Manager, Health, Safety, and Environment, U.S. Department of Energy, Savannah River Plant.</p> | <p>TC</p> |
| <p>Sires, M. J., 1984b. <u>Supplemental Information: Proposed Operation of the Savannah River Plant (SRP) L-Reactor and the American Alligator</u>, letter and enclosed biological assessment to Warren J. Parker, Field Supervisor, Endangered Species Field Station, U.S. Fish and Wildlife Service, March 29, 1984.</p> | <p>AP-6,
AY-2,
BA-6,
CV-1</p> |
| <p>Sires, M. J., 1984c. <u>Biological Assessment for the Wood Stork and Operation of the Savannah River Plant</u>, letter to James W. Pulliam, Jr., Regional Director, U.S. Fish and Wildlife Service, March 29, 1984.</p> | |
| <p>USDOI (U.S. Department of the Interior), 1981. "U.S. Fish and Wildlife Service Mitigation Policy; Notice of Final Policy." <u>Federal Register</u>, Volume 46, Number 15, pp. 7644-7663.</p> | <p>TC</p> |

8 UNAVOIDABLE/IRREVERSIBLE IMPACTS

Impacts that cannot be avoided by reasonable mitigation measures are described in Section 8.1; these impacts are based on the reference case (direct discharge to Steel Creek). Impacts that differ from those caused by the preferred cooling alternative (described in Chapter 4 and Appendix L) are noted. Other individual mitigation alternatives would have smaller unavoidable and irreversible impacts. Section 8.2 describes commitments of resources and Section 8.3 outlines short-term versus long-term implications.

AM-5,
FR-27

8.1 UNAVOIDABLE ADVERSE IMPACTS

The unavoidable adverse impacts expected from the resumption of L-Reactor operation have all been experienced previously to either the same or a greater extent during the past operation of L-Reactor.

An additional 11 cubic meters per second of cooling water would be withdrawn from the Savannah River. This withdrawal would cause entrainment and impingement of aquatic biota (Section 5.2.4). The resumption of direct discharges of thermal effluents from reactor operation to Steel Creek (reference case) would impact between 730 and 1000 acres of wetlands and the wildlife supported by this habitat. Some habitat for the American alligator, waterfowl, and wood stork would be eliminated. The preferred cooling alternative would impact between 735 and 1015 acres of wetlands and 875 acres of uplands. Some habitat for the alligator, waterfowl, wood stork, and other wildlife would also be eliminated.

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For the reference case, the use of Steel Creek above its delta by fish would be significantly reduced. During the months of March, April, and May, thermal effluents from Steel Creek would block fish access to Boggy Gut Creek wetland areas (230 acres) and prevent spawning in this offsite creek. Thermal discharges would also increase the thermal plume in the Savannah River; however, a zone of passage for fish would be maintained. The impacts would be reduced with the preferred (1000-acre lake) cooling alternative, although the headwaters of Steel Creek would not always be available to fish. During winter, the temperature of Steel Creek below the embankment would be 7° to 9°C above ambient, leading to the possibility of cold shock. However, reactor shutdowns during the winter would result in gradual heat loss in this area, which would minimize any cold shock effects. Aquatic biota would be able to utilize the swamp and delta for spawning and feeding purposes.

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Unavoidable radiation exposure would include increased occupational exposures and exposures to the general public due to normal reactor operations, and the resuspension of radiocesium and cobalt-60 from Steel Creek. The occupational and public exposures (Section 4.1.2) would be minimal compared to those from natural and other manmade radiation sources.

8.2 IRREVERSIBLE AND/OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Energy, raw material, and other resources would be consumed in the operation of L-Reactor. Resources that could be irreversibly or irretrievably committed during operation of facilities include (1) materials that cannot be recovered or recycled, and (2) materials consumed or reduced to unrecoverable forms.

Resumption of L-Reactor operation would involve only land previously committed. However, final disposal of low-level radioactive waste associated with L-Reactor operation would probably involve additional land use (ERDA, 1977).

Irretrievable energy use would amount to 40-50 megawatt-years of electricity per year, 5.8×10^3 metric tons of coal per year, and 1.5×10^6 liters of diesel fuel per year. Additionally, process chemicals would be consumed and/or converted to unrecoverable forms. Other irretrievable resources would include contaminated materials and/or equipment that could not be reused.

8.3 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The short-term effects of L-Reactor operation include the unavailability of site areas for their natural productivity and wildlife habitat. However, this area has been committed for energy and defense activities since 1951. Following decommissioning and decontamination (Section 4.6), this area can revert back to its natural state with minimal long-term effects.

AM-5, FR-27 | In the short term, L-Reactor operation would impact wetlands, wetlands habitat, and aquatic biota due to cooling-water withdrawal and thermal effluent discharge. There would be loss of a portion of local habitat for endangered species (e.g., the American alligator, and the wood stork). In the long term, after termination of L-Reactor operation, wetlands below the cooling lake embankment could become established through the process of natural succession. Emergent, nonwoody hydrophytes could become reestablished within months, depending upon the season when flow is terminated, and other habitat factors. Vegetation characteristic of bottomland and swamp wetlands would take longer. In 1981, 13 years after the shutdown of L-Reactor, the Savannah River swamp had only begun to return to its former composition and structure (Repaske, 1981). The 1000-acre lake would provide habitat for aquatic and semiaquatic biota.

AM-5, FR-27 | Solid nonradioactive waste generated from L-Reactor would use additional land at a landfill site that will be unavailable for alternative uses. Additional space would be required at an already designated burial ground site for radiological solid waste generated by L-Reactor.

High-level radioactive waste from L-Area would require additional waste processing (DOE, 1982) and disposal in a geologic repository with the commitment of associated land and other resources.

REFERENCES

- DOE (U.S. Department of Energy), 1982. Final Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, DOE/EIS-G082, Aiken, South Carolina.
- ERDA (Energy Research and Development Administration), 1977. Final Environmental Impact Statement, Waste Management Operations, Savannah River Plant, ERDA-1537, Aiken, South Carolina.
- Repaske, W. A., 1981. Effects of Heated Water Effluents on the Swamp Forest at the Savannah River Plant, South Carolina. Master Thesis, University of Georgia, Athens, Georgia.

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<u>EIS RESPONSIBILITY</u>	Contributor to Sections 4.1.2, 5.1.2, 5.2.6, and 5.2.7, and Appendix B.

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ALLENDALE COUNTY CITIZEN LEADER

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WFBC-TV (Channel 4)

WJWJ-TV (Channel 16 ETV)

WCBD-TV Mt. Pleasant
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GLOSSARY

abatement

Method for reducing the degree or intensity of an environmental impact; also the use of such a method.

absorbed dose

Energy transferred to matter when ionizing radiation passes through it. Absorbed dose is measured in rads.

absorber

Material, such as concrete and steel shielding, that absorbs and diminishes the intensity of ionizing radiation.

absorption

The process by which the number and energy of particles or photons entering a body of matter are reduced by interaction with the matter.

acclimation

The physiological and behavioral adjustments of an organism to changes in its immediate environment.

acclimatization

The acclimation or adaptation of a particular species over several generations to a marked change in the environment.

activation

The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.

activation products

Nuclei formed by the bombardment of material with neutrons, protons, or other nuclear particles.

activity

A measure of the rate at which a material is emitting nuclear radiation, usually given as the number of nuclear disintegrations per unit of time. A unit of radioactivity is the curie (Ci), which equals 3.7×10^{10} disintegrations per second.

adaptation

A change in structure or habit of an organism that produces better adjustment to the environment.

adsorption

The adhesion of a substance to the surface of a solid or solid particles.

AEC

Atomic Energy Commission. A five-member commission established by the Atomic Energy Act of 1954 to supervise the use of nuclear energy. The AEC was dissolved in 1975 and its functions transferred to the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), which became the Department of Energy (DOE).

aerobic

Processes that can occur only in the presence of oxygen.

air quality

A measure of the levels of pollutants in the air.

air quality standards

The prescribed level of pollutants in the outside air that cannot be exceeded legally during a specified time in a specified area.

air sampling

The collection and analysis of air samples for detection or measurement of radioactive substances.

alluvial

Deposited by a stream or running water.

alpha (α) particle

A positively charged particle, consisting of two protons and two neutrons, that is emitted during certain radioactive decay, from the nucleus of certain nuclides. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

ambient air

The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. (It is not the air in immediate proximity to emission sources.)

anaerobic

Processes that occur in the absence of oxygen.

anion

A negatively charged ion.

aquatic biota

The sum total of living organisms of any designated aquatic area.

aquifer

An underground bed or stratum of earth, gravel, or porous stone that contains water. The water can be pumped to the surface through a well or it might emerge naturally as a spring.

archeological sites (resources)

Areas or objects modified or made by man and the data associated with these features and artifacts.

arcuate

A curved or bent axial trace in a fold. (The fold would be called arcuate.)

arenaceous limestone

Limestone with a texture or appearance of sand.

arkosic

Having wholly or in part the character of arkose, which is a sandstone containing 25 percent or more of feldspars, usually derived from silicic igneous rocks (e.g., granite).

artifact

An object produced or shaped by human workmanship of archeological or historical interest.

ash

Inorganic residue remaining after ignition of combustible substances.

atmosphere

The layer of air surrounding the earth.

backfill

Material used to refill an excavation.

background exposure

See exposure to radiation.

background radiation

Normal radiation present in the lower atmosphere from cosmic rays and earth sources. Background radiation varies considerably with location.

bedrock

Any solid rock exposed at the earth's surface or overlain by unconsolidated surface material such as soil, gravel, or sand.

bedroom community

An area, adjacent to a city, where a large number of individuals who work in the city reside.

benthic region

The bottom of a body of water. This region supports the benthos, a type of life that not only lives upon but contributes to the character of the bottom.

benthos

The plant and animal life whose habitat is the bottom of a sea, lake, or river.

beta particle

An elementary particle emitted from a nucleus during radioactive decay. It is negatively charged, is identical to an electron, and is easily stopped, such as by a thin sheet of metal.

biological dose

The radiation dose, measured in rems, absorbed in biological material.

biological oxygen demand (BOD)

A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the amount of organic waste in water, the greater the BOD.

biological shield

A mass of absorbing material placed around a radioactive source to reduce the radiation to a level safe for humans.

biosphere

The portion of the earth and its atmosphere capable of supporting life.

biostratigraphy

The study of stratigraphy via fossilized remains.

biota

The plant and animal life of a region.

BOD

See: Biological oxygen demand.

borosilicate glass

A strong chemically resistant glass made primarily of sand and borax. As a waste form, high-level waste is incorporated into the glass to form a leach-resistant, nondispersible (immobilized) material.

Btu

British Thermal Unit, a unit of heat. The quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit. One Btu equals 1055 joules (or 252 calories).

building codes

Legislative regulations which prescribe the materials, minimum requirements, and methods used in the construction, rehabilitation, maintenance, and repair of buildings and other structures.

burial ground

A place for burying unwanted radioactive materials in which the earth acts as a shield to prevent escape of radiation. In this EIS, materials are incorporated into concrete to prevent leaching of materials or movement in the underground environment.

°C

Degree Celsius. The Celsius temperature scale is related to the Fahrenheit scale as follows:

$$^{\circ}\text{F} = ^{\circ}\text{C} \times \frac{9}{5} + 32.$$

calcareous cement

Calcium carbonate based cement.

calcine

The process in which the water portion of the slurried waste is driven off by evaporation at high temperature in a spray chamber leaving a residue of dry solid unmelted particles, also referred to as the calcine.

cancer

The name given to a group of diseases that are characterized by uncontrolled cellular growth.

canister

A metal (steel) container into which immobilized radioactive waste is sealed.

canyon building

A heavily shielded building used in the chemical processing of radioactive materials. Operation and maintenance are by remote control.

carbon monoxide

A colorless, odorless gas that is toxic if breathed in high concentration over a certain period of time. It is a normal component of most automotive exhaust systems.

carcinogen

An agent capable of producing or inducing cancer.

carcinogenic

Capable of producing or inducing cancer.

carolina bay

Wetland area found on the Southeastern Atlantic coastal plain. A shallow depression.

cask

A heavily shielded massive container for holding a canister of HLW during shipment of the immobilized radioactive material.

cc

Cubic centimeters, cm^3 or cc (1 cc = 1 milliliter).

CCDF

Complementary cumulative distribution function.

cfm

Cubic feet per minute.

cfs

Cubic feet per second.

C1

See: Curie.

clarifier

A tank or other vessel to accomplish removal of settleable solids (e.g., in this EIS, the liquid waste transfer operations include transfer to a clarifier in which the sludge solids settle and the liquid is clarified).

clastic dike

A sedimentary dike formed by broken rocks from overlying or underlying material.

commercial HLW

High-level radioactivity waste materials produced by commercial operations. Most of such waste is produced by commercial nuclear power plants; it is the spent nuclear fuel from such plants or the product of reprocessing such fuels. Such wastes are distinguished from wastes produced in processing defense materials.

common carriers

The vehicles, such as trucks, trains, barges, and planes that are licensed to transport the wide assortment of goods and materials distributed regularly across the country.

concentration

The quantity of a substance contained in a unit quantity of a sample.

condensate

Liquid water obtained by cooling the steam (overheads) produced in an evaporator system. Also, any liquid obtained by cooling saturated vapor.

CO₂

Carbon dioxide, a colorless, odorless, nonpoisonous gas that is a normal component of the ambient air.

coolant

A substance, usually water, circulated through a processing plant to remove heat.

cooling tower

A structure designed to cool water by evaporation. In this EIS, the water being cooled was heated by absorbing heat in order to condense the steam in the evaporator system.

correlatable

Able to establish a connection between geological formations or events.

cretaceous

End of mesozoic era, between 136 and 65 million years ago.

crystalline metamorphic rock

Rock consisting wholly of crystals.

cuesta

A ridge formed from sedimentary rock, steep on one side, but with a gentle slope on the other.

cumulative effects

Additive environmental, health, and socioeconomic effects that result from a number of similar activities in an area.

curie (Ci)

A unit of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second. A curie is also a quantity of any nuclide or mixture of nuclides having one curie of radioactivity.

daughter

A nuclide formed by the radioactive decay of another nuclide, which is called the parent.

decay heat

The heat produced by the decay of radioactive nuclides.

decay, radioactive

The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in the emission of nuclear radiation (alpha, beta, or gamma radiation).

decommissioning

Removing facilities such as processing plants, waste tanks, and burial grounds from service and reducing or stabilizing radioactive contamination. Decommissioning concepts include:

- o The decontamination, dismantling, and return of an area to its original condition without restrictions.
- o Partial decontamination, isolation of remaining residues, and continued surveillance and restrictions.

decomposition

The breakdown of a substance into its constituent parts.

decontamination

The removal of radioactive contaminants. This removal can be from surfaces of equipment, as by cleaning or washing with chemicals, or by wet abrasive blasting using glass frit and water (to decontaminate the filled canisters). Also, the removal of high-level radioactivity nuclides from within a material (e.g., from high-level radioactivity liquid defense wastes).

defense waste

Nuclear waste generated from government defense programs as distinguished from waste generated by commercial and medical facilities.

demography

The statistical study of human populations including population size, density, distribution, and vital statistics such as age, sex, and ethnicity.

depositional regimes

A systematic laying or throwing down of material over a substantial area.

detector

Material or device (i.e., instrument) that is sensitive to radiation and can produce a response signal suitable for measurement or analysis.

detritus

Dead organic tissues and organisms in an ecosystem.

diesel generator

A machine powered by diesel fuel that converts mechanical energy into electricity.

diesel oil

An oil fraction produced in processing crude oil, which is used to fuel diesel engines.

dip

The angle that a structural surface (e.g., a bedding or fault plane) makes with the horizontal, measured perpendicular to the strike of the substance.

disposal

Placement of HLW in a repository in such a manner that the materials remain isolated from the environment permanently or until radioactive nuclides have decayed to harmless levels.

distillation

Separation process achieved by creating two or more coexisting zones which differ in temperature, pressure, or composition.

DOE

United States Department of Energy.

dose

The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram of irradiated material in any medium.

dose commitment

The dose which an organ or tissue would receive during a specified period of time (e.g., 50 or 100 years) as a result of intake (as by ingestion or inhalation) of one or more radionuclides from 1-year's release.

dose equivalent

A term used to express the amount of effective radiation when modifying factors have been considered. It is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. It is measured in rems (Roentgen equivalent man).

dose rate

The radiation dose delivered per unit time (e.g., rems per year).

dosimeter

A small device (instrument) that measures radiation dose (e.g., film badge or ionization chamber) and is carried by a radiation worker.

drawdown

The height difference between the water level in a formation and the water level in a well caused by the withdrawal of ground water.

drift

Mist or spray carried out into the atmosphere with the effluent air from cooling towers.

DWPF

Defense Waste Processing Facility, under construction at SRP; it is designed to process defense waste into a suitable form for terminal storage or disposal.

D₂O

Heavy water or deuterium oxide.

ecology

The science dealing with the relationship of all living things with each other and with the environment.

ecosystem

A complex of the community of living things and the environment forming a functioning whole in nature.

EDC

See: Environmental dose commitment.

effluent

A liquid waste, discharged into the environment, usually into surface streams. In this EIS, effluent refers to discharged wastes that in their natural state or as a result of treatment are nonpolluting.

effluent standards

Defined limits of waste discharge in terms of volume, content of contaminants, temperature, etc.

EIS

Environmental impact statement, a document prepared pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA) for a major Federal action significantly affecting the quality of the human environment.

electron

An elementary particle with a unit negative charge and a mass 1/1837 of the proton. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

element

One of the 105 known chemical substances that cannot be divided into simpler substances by chemical means. All nuclides of an element have the same atomic number.

eluate

The liquid resulting from removing the trapped material from an ion-exchange resin.

emission standards

Legally enforceable limits on the quantities and/or kinds of air contaminants that may be emitted into the atmosphere.

endangered species

Plants and animals in an area that are threatened with either extinction or serious depletion of a species.

energy

The capacity to produce heat or do work. Electrical energy is measured in units of kilowatt-hours.

environment

The sum of all external conditions and influences affecting the life, development, and ultimately, the survival of an organism.

environmental dose commitment (EDC)

A dose representing exposure to and ingestion of environmentally available radionuclides for 100 years following a one-year release of radioactivity.

environmental fate

The result of the physical, biological, and chemical interactions of a substance released to the environment.

environmental transport

The movement through the environment of a substance; it includes the physical, chemical, and biological interactions undergone by the substance.

eocene

Lower tertiary period, after paleocene but before oligocene.

epidemiology

The study of diseases as they affect populations.

epoch

Length of time (geology).

erosion

The process in which uncovered soil and clay are carried away by the action of wind or water.

estuarine

Pertaining to an area where salt and fresh water come together, and are affected by tides.

exchange resin

Polymeric spheres containing bounded groups that carry an ionic charge, either positive or negative, in conjunction with free ions of opposite charge that can be displaced.

exposure to radiation

The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation which takes place during a person's working hours. Population exposure is the exposure to a number of persons who inhabit an area.

°F

Degree Fahrenheit. The Fahrenheit temperature scale is related to the Celsius scale as follows:

$$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}.$$

facies

A group of rocks that differ from surrounding rocks.

fall line

Imaginary line marking the point that most rivers drop steeply from the uplands to the lowlands.

fallout

The descent to earth and deposition on the ground of particulate matter (which may be radioactive) from the atmosphere.

fanglomerates

Sedimentary rock of water-worn heterogeneous fragments of every size, settling in an alluvial fan and cementing into rock.

fault

A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage has occurred in the past.

faunal

Animal and plant fossils of a certain rock unit.

feldspar

Most common group of aluminum silicate minerals (containing other metals, such as potassium, sodium, and iron) that form rock.

ferruginous

Containing iron oxide.

fission

The splitting of a heavy atomic nucleus into two approximately equal parts, which are nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or can be induced by neutron bombardment.

fission products

Nuclei formed by the fission of heavy elements (primary fission products). Also the nuclei formed by the decay of the primary fission products, many of which are radioactive.

fluvial

Relating to or living in, or near a river.

flux

Rate of flow through a unit area.

food chain

The pathways by which any material entering the environment passes from the first absorbing organism through plants and animals to humans.

fracture porosity

Breaking in a rock resulting in porosity.

fuel

A substance used to produce heat (e.g., from chemical energy by combustion, or from nuclear energy by nuclear fission).

fuller's earth

Fine grained natural earth substance. Has high absorbency. Consists mostly of hydrated aluminum silicates.

gal

Gallons.

gamma rays (γ)

High-energy, short-wavelength electromagnetic radiation accompanying fission and emitted from the nucleus of an atom. Gamma rays are very penetrating and require dense (e.g., lead) or a thick layer of materials for shielding.

gamma spectrometry

Identification and quantification of radioisotopes by measurement of the characteristic gamma rays emitted by elements undergoing radioactive decay.

generator

A machine that converts mechanical energy into electrical energy; a diesel generator is one that utilizes diesel fuel.

genetic effects

Radiation effects that can be transferred from parent to offspring; radiation-induced changes in the genetic material of sex cells.

geologic repository (mined geologic repository)

A facility for the disposal of nuclear waste. The waste is isolated by placing it within a continuous, stable geologic formation at depths greater than 1000 feet.

geology

The science that deals with the earth: the materials, processes, environments and history of the planet especially the lithosphere, including the rocks, their formation and structure.

g/L

Grams per liter.

glass frit

Ground or powdered glass.

glaucconitic

Mineral aggregate containing glauconite, giving it a green color.

gneiss

Rock formed from bands of granular minerals alternating with bands of minerals that are flakey, or have elongate prismatic habits.

gpm

Gallons per minute.

gradient

Slope, particularly of a stream or land surface.

ground water

The supply of water under the earth's surface in an aquifer.

gypsum

Mineral containing hydrous calcium sulfate.

half-life (biological)

The time required for a living organism to eliminate, by natural processes, half the amount of a substance that has entered it.

half-life (effective)

The time required for a radionuclide contained in an organism to reduce its activity by one half as a combined result of radioactive decay and biological elimination.

half-life (radiological)

The time in which half the atoms of a radioactive substance disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years.

half-thickness

The thickness of any absorber that will reduce the intensity of a beam of radiation to one half its initial intensity.

halogens

The group of five chemically related nonmetallic elements that include fluorine, chlorine, bromine, iodine, and astatine.

hardwoods

Trees which are an angiosperm and yield wood which has a hard consistency.

health physics

The science concerned with recognition, evaluation, and control of health hazards from ionizing radiation.

heat exchanger

A device that transfers heat from one fluid (liquid or gas) to another or to the environment.

heating value

The heat released by combustion of a unit quantity of a fuel, measured in joules or Btu's.

heavy metals

Metallic elements of high molecular weight, such as mercury, chromium, cadmium, lead, and arsenic, that are toxic to plants and animals at known concentrations.

heavy water

Water in which the molecules contain deuterium, an isotopic form of hydrogen which is heavier than ordinary hydrogen, and oxygen.

hectare

A metric unit of area equal to 2.471 acres.

HEPA

High efficiency particulate air filter. A type of filter designed to remove 99.9% of the particles down to 0.3 mm in diameter from a flowing air stream.

high-level waste

High-level liquid waste or the products from the solidification of high-level liquid waste or irradiated fuel elements if discarded without re-processing. Also see: Commercial HLW; Defense waste.

historic resources

The sites, districts, structures, and objects considered limited and non-renewable because of their association with historic events, persons, or social or historic movements.

HLW

High-level radioactive waste. (Also see: Commercial HLW; Defense waste).

holocene

Epoch of quaternary period from end of pleistocene to present time.

horneblende

Most common mineral of the amphibole group.

HSU

Hydrostratigraphic unit.

hydraulic conductivity

Water flow rate in gallons per day through a one square foot cross section under a unit hydraulic gradient.

hydraulic (water) head

Height of water with a free surface above a subsurface point.

hydrocarbons (HC)

Organic compounds consisting primarily of hydrogen and carbon. Hydrocarbons are emitted in automotive exhaust and from the incomplete combustion of fossil fuels such as coal.

hydrograph

Graph showing water characteristics such as velocity, or flow, in relation to time.

hydrologic regimen

Total quantity and characteristic behavior of water in a drainage basin.

hydrology

The science dealing with the properties, distribution, and circulation of natural water systems.

hydrosphere

The water portion of the surface of the earth as distinguished from the solid portion, the lithosphere.

hydrostratigraphic unit

Rock or soil body extending laterally for a considerable distance. (Sometimes abbreviated HSU.)

immobilization

Conversion of HLW into a form that will be resistant to environmental dispersion.

incorporated places

Political units incorporated or combined as cities, boroughs, towns, and villages.

indigenous labor pool

An area's native labor pool composed of workers normally residing in the area, who do not leave the area upon termination of a construction project.

induced radioactivity

Radioactivity that is created when substances are bombarded with neutrons as in a reactor.

indurated

Soil or rock compacted and hardened by heat, pressure, and cementation.

inert gas

A gas that is totally unreactive.

in-movers

Workers who move into an area during construction and leave when the project is finished. As used in this document, in-movers also include some weekly travelers.

intensity

The energy or the number of photons or particles of radiation incident upon a unit area per unit of time. Intensity of radioactivity is the number of atoms disintegrating per unit of time.

interfluvial

Falling in the area between two streams.

intergranular porosity

Porosity between grains of rock.

interim storage

Temporary storage of sealed canisters containing immobilized HLW in a shielded storage vault until transfer to a Federal repository.

ion

An atom or molecule that has gained or lost one or more electrons and thus has become electrically charged.

ion exchange

Process in which a solution, containing soluble ions to be removed, is passed over a solid ion exchange column, which removes the soluble ions by exchanging them with labile ions from the surface of the column. The process is reversible, so the trapped ions can be eluted from the column and the column regenerated.

ionization

The process whereby ions are created. Nuclear radiation can cause ionization as can high temperatures and electric discharges.

ionizing radiation

Radiation capable of displacing electrons from atoms or molecules thereby producing ions.

irradiation

Exposure to radiation.

isotope

An atom of a chemical element with a specific atomic number and atomic weight. Isotopes of the same element have the same number of protons but different numbers of neutrons.

joule

A unit of energy or work which is equivalent to one watt per second or 0.737 foot-pounds or 4.18 calories.

kaolin

Clay mineral group characterized by a silicon oxygen sheet, and an aluminum-hydroxyl sheet alternately linked to form a two-layer crystal lattice.

kilometer

A metric unit of length equal to 0.62137 mile.

leachate

Liquid that has percolated through solid waste or other media and has extracted from the solids dissolved or suspended materials into the liquids.

leaching

The process whereby a soluble component of a solid or mixture of solids is extracted as a result of percolation of water around and through the solid.

leukemia

A form of cancer characterized by extensive proliferation of nonfunctional immature white blood cells (leukocytes).

lignite

A brownish-black coal between stages of peat and subbituminous coal.

limonite

Hydrous ferric oxides occurring naturally, but having unknown origins.

liquid HLW

The aqueous high-level radioactive waste resulting from the production of nuclear materials at SRP.

liters per second

A metric unit of flow rate equal to 15.85 gallons per minute.

lithology

Rock descriptions by color, structure, grain size, etc.

lithosphere

The solid part of the earth composed predominantly of rock.

long-lived nuclides

Radioactive isotopes with half-lives greater than about 30 years.

low-level waste

Radioactive waste not classified as high-level waste. The wastes (mostly salts) remaining after removal of the highly radioactive nuclides from the liquid high-level wastes for immobilization.

man-rem

The radiation dose commitment to a given population; the sum of the individual doses received by a population segment.

marine terrace

Narrow coastal strip altered by marine deposit and erosion.

maximum permissible dose

That dose of ionizing radiation established by competent authorities as an amount below which there is no appreciable risk to human health and which at the same time is below the lowest level at which a definite hazard is believed to exist.

megawatt (MW)

A unit of power equal to 1,000 kilowatts (kW) or one million (10^6) watts.

mg

Milligram (one-thousandth of a gram).

mica

Variously colored, or colorless mineral silicates, crystallizing in monoclinic forms that separate into thin leaves.

micro (μ)

Prefix indicating one millionth. One microgram = $1/1,000,000$ of a gram or 10^{-6} gram.

micrometer (μm)

A unit of length equal to one one-millionth (10^{-6}) of a meter.

micron

A micrometer (10^{-6} meters).

migration

The natural travel of a material through the air, soil, or ground water.

ml

Milliliter (one-thousandth of a liter).

mm

Millimeter (one-thousandth of a meter).

mobility

The ability of a chemical element or a pollutant to move into and through the environment.

moderator

A material used to slow down neutrons from fission to thermal energies.

molecule

A group of atoms held together by chemical forces. A molecule is the smallest unit of a compound that can exist by itself and retain all its chemical properties.

monitoring

Process whereby the level and quality of factors that can affect the environment and/or human health are measured periodically in order to regulate and control potential impacts.

monoclinal

Strata varying from the horizontal in one direction only.

mrem

Millirem (1/1,000 of a rem).

mutagen

An agent, physical, chemical, or radiative, capable of inducing mutation (above the spontaneous background level).

mutagenesis

The occurrence or induction of mutation, a genetic change that is passed on from parent to offspring.

mutation

An inheritable change in the genetic material (in a chromosome).

nano

Prefix indicating one thousandth of a micro unit; one trillionth;
1 nanocurie = 10^{-9} curie.

National Register of Historic Places

A list maintained by the National Park Service of architectural, historical, archaeological, and cultural sites of local, state, or national significance.

natural radiation or natural radioactivity

Background radiation.

nCi

Nanocuries, 10^{-9} curies.

NEPA

National Environmental Policy Act of 1969.

neutron

An uncharged elementary particle with a mass slightly greater than that of the proton and found in the nucleus of every atom heavier than hydrogen-1. A free neutron is unstable and decays with a half life of about 13 minutes into an electron and a proton.

neutron flux

Number of neutrons flowing through a specified area per unit time.

NH₃

Ammonia, a pungent reactive colorless gas, which is irritating to the eyes and moist skin in high concentrations.

NO_x

Refers to the oxides of nitrogen, primarily NO and NO₂. These are often produced in the combustion of fossil fuels. In²high concentration they constitute an air pollution problem.

nodes

The intersection of horizontal and vertical grids.

NRC

Nuclear Regulatory Commission.

nuclear energy

The energy liberated by a nuclear reactor (fission or fusion) or by radioactive decay.

nuclear power plant

A facility that converts nuclear energy into electrical power. Heat produced by a reactor is used to make steam to drive a turbine which drives an electric generator.

nuclear reaction

A reaction in which an atomic nucleus is transformed into another element, usually with the liberation of energy as radiation.

nuclear reactor

A device in which a fission chain reaction is maintained and which is used for irradiation of materials or the generation of electricity.

nucleus

The small positively charged core of an atom, which contains nearly all of the mass of the atom.

nuclide

An atomic nucleus specified by its atomic weight, atomic number and energy state. A radionuclide is a radioactive nuclide.

organic degreasers

Cleaning agents having organic chemical structures.

outcrop

Part of a geologic formation above the surface of the earth.

paleocene

Epoch of tertiary period between the gulfian of the cretaceous period and before the eocene.

particulates

Solid particles small enough to become airborne.

pascal

A metric unit of pressure. 101,000 pascals is equal to 14.7 psi (1 atmosphere).

pD

The negative log of the deuterium (heavy hydrogen) ion concentration in solution; analogous to the term pH, which refers to the normal hydrogen ion concentration.

penplain

Almost featureless, plain land surface.

perched

A water-bearing area of small lateral dimensions lying above a more extensive aquifer.

permeability

Ability for water to flow through a porous rock, or soil.

pH

A measure of the hydrogen ion concentration in aqueous solution; specifically, the negative logarithm of the hydrogen ion concentration. Acidic solutions have a pH from 0 to 7, basic solutions have a pH greater than 7.

phosphatic marl

Soft, loose, earthy phosphates that crumble easily.

photon

Electromagnetic radiation; a quantum of electromagnetic energy having properties of both a wave and a particle but without mass or electric charge.

physiography

Description of earth surface features, including air and water as well as land.

piedmont province

Large area forming a plateau at the base of the Appalachian mountains, extending from New Jersey to Alabama.

piezometric maps

Lines of equal groundwater pressure drawn on a map.

piezometric surface

The surface to which water in an aquifer would rise by hydrostatic head.

pisolitic clay

Clay that exhibits an internal structure of pea-sized clay grains.

plant stream

Any natural stream on the SRP site. Surface drainage of the site is via these streams to the Savannah River.

pleistocene

Epoch of the quaternary period, between pliocene and holocene.

pliocene

Epoch of the tertiary period, between miocene and pleistocene.

plume

The visible emission from a flue or chimney.

pollution

The addition of any undesirable agent to an ecosystem in excess of the rate at which they can be degraded, assimilated, or dispersed by natural processes.

ppb

Parts per billion (10^{-9}), one thousandth of a part per million.

ppm

Parts per million. The unit is commonly used to represent the degree of pollutant concentration when the concentration is small. In air, ppm is usually volume pollutant/1,000,000 volumes of air; in water, a weight/1,000,000 weight units.

primary road

Interstate, state, and regional routes including rural arterial routes and their extensions into or through urban areas.

psi

Pounds per square inch, a measure of pressure. Atmospheric pressure is about 15 psi.

pyrite

Isometric mineral: FeS_2 (iron sulfide).

quality factor

The factor by which absorbed dose, in rads, is multiplied to obtain a quantity expressing the irradiation incurred by various biological tissues taking into account the biological effectiveness of the various types of radiation.

quartz

Crystalline silica: SiO_2 .

quartzite

Very hard, metamorphosed sandstone.

quaternary age

The period from the end of the tertiary to present time.

rad

Acronym for radiation absorbed dose; is the basic unit of absorbed dose equal to the absorption of 0.01 joules per kilogram of absorbing material.

radiation

The emitted particles and/or photons from the nuclei of radioactive atoms. Some elements are naturally radioactive whereas others are induced to become radioactive by bombardment in a reactor. Naturally occurring radiation is indistinguishable from induced radiation.

radiation detection instrument

Devices that detect and record the characteristics of ionizing radiation.

radiation monitoring

Continuous or periodic determination of the amount of radiation present in a given area.

radiation protection

Legislation, regulations, and measures to protect the public or laboratory of industrial workers from harmful exposure to radiation.

radiation shielding

Reduction of radiation by interposing a shield of absorbing material between a radioactive source and a person, laboratory area, or radiation-sensitive device.

radiation standards

Permissible exposure levels of radiation and regulations governing same.

radioactivity

The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

radioisotopes

Nuclides of the same element (same number of protons in their nuclei) which differ in the number of neutrons, and which spontaneously emit particles or electromagnetic radiation.

receiving waters

Rivers, lakes, oceans, or other bodies of water into which treated or untreated waste waters are discharged.

rem

Acronym for roentgen equivalent man; is the unit of dose for biological absorption. It is equal to the product of the absorbed dose in rads and a quality factor and a distribution factor.

repository

A facility for the terminal storage or disposal of spent nuclear fuel or immobilized HLW.

residence time

The period of time during which a substance resides in a designated area.

resin

An organic polymer used as an ion-exchange material.

roentgen (R)

A unit of exposure to ionizing radiation equal to or producing one coulomb of charge per cubic meter of air.

runoff

The portion of rainfall, melted snow, or irrigation water that flows across ground surface and eventually is returned to streams. Runoff can carry pollutants into receiving waters.

saltcake

The crystallized salts (primarily nitrates and nitrites) resulting from the evaporation of liquid HLW.

saltcrete

A mixture of partially decontaminated salts and concrete.

sandstone

Clastic rock containing large individual particles visible to the unaided eye.

sanitary landfilling

An engineered method of solid waste disposal on land in a manner that protects the environment; waste is spread in thin layers, compacted to the smallest practical volume, and covered with soil at the end of each working day.

saprolite

A rock that is earthy, soft, clay-rich, extremely decomposed.

schist

Strongly foliated crystalline rock formed by dynamic metamorphism that can easily be split into thin slabs, or flakes.

screen

Tool used to allow particles of a certain size through while separating out larger particles.

scrubber

An air pollution control device that uses a liquid spray to remove pollutants from a gas stream by absorption or chemical reaction.

secondary road

A rural major collector route.

sedimentation

The settling of excess soil and mineral solids of small particle size contained in water.

seep lines

Small zone where water leachate percolates slowly to the surface; a series of ground water or leachate springs.

seepage basin

An excavation in the ground to receive aqueous streams containing chemical and radioactive wastes. Insoluble materials settle out on the floor of the basin and soluble materials seep with the water through the soil column where they are removed partially by ion exchange with the soil. Construction includes dikes to prevent overflow or surface runoff.

seismic

Pertaining to any earth vibration, especially an earthquake.

seismicity

The tendency for the occurrence of earthquakes.

settling tank

A tank in which settleable solids are removed by gravity.

sewage

The total of organic waste and wastewater generated by an industrial establishment or a community.

sewer

Any pipe or conduit used to collect and carry away sewage or stormwater runoff.

sewerage

The entire system of sewage collection, treatment, and disposal.

shield

An engineered body of absorbing material used to protect personnel from radiation.

short-lived nuclides

Radioactive isotopes with half lives no greater than about 30 years (e.g., cesium-137 and strontium-90).

siderite nodule

A small clump or knot of a rhombohedral mineral: FeCO_3 .

siliceous cement

Cement with an abundance of silica.

siltstone

Silt having the texture and composition of shale, but lacking its fine lamination.

sink

An area from which water drains or is removed.

sludge

The precipitated solids (primarily oxides and hydroxides) that settle to the bottom of the storage tanks containing liquid HLW.

slug

Small, isolated body of water.

slurry

A suspension of solid particles (sludge) in water.

socioeconomic baseline characterization

A description and discussion of a study area's social and economic characteristics including a profile of local government, housing supply, land use, and public and private services.

softwoods

Trees, particularly evergreens and shrubs, that produce seeds in a cone.

SO₂

Sulfur dioxide; a heavy pungent colorless gas (formed in the combustion of coal). SO₂ in high concentration is considered a major air pollutant.

SO_x

The oxides of sulfur, primarily SO₂ and SO₃. SO_x is a common air pollutant.

sparger

A discharge nozzle which provides quick dispersion of one fluid (liquid or gas) into another.

spill

The accidental release of radioactive material.

spray irrigation

The practice of dispersing treated aqueous effluents by spraying land in controlled amounts. Treated effluent is rich in nutrients that may be utilized by plants.

SREL

Savannah River Ecological Laboratory, an ecology research institution operated by the University of Georgia under contract from DOE.

SRL

Savannah River Laboratory.

SRP

Savannah River Plant.

stable

Not radioactive.

stack

A vertical pipe or flue designed to exhaust gases and suspended particulate matter.

stack gases

Gases emitted from a stack.

stationary source

A source of emissions into the environment that is fixed rather than moving, as an automobile.

storage

Retention of radioactive waste in man-made containment such as a tank or vault in a manner permitting retrieval as distinguished from disposal which implies no retrieval.

storage coefficient

Volume of water released from storage in a vertical column of 1.0 sq. ft. when the water table declines 1.0 ft.

stratified

Formed or arranged in layers.

stratigraphy

Division of geology dealing with the definition and description of rocks and soil both major and minor natural divisions.

strike

The direction or trend that a structural surface (e.g., a bedding or fault plane) takes as it intersects the horizontal.

study area

A specific geographic area isolated from surrounding areas for the purpose of examining and analyzing specific phenomena and activities.

supernatant, supernate

The liquid portion of the liquid HLW that consists of water and materials in solution in the water.

surface water

All water on the surface, as distinguished from groundwater.

surficial deposit

Most recent geological deposit lying on bedrock or on or near the earth's surface.

surveillance

A monitoring system designed to assure safe and secure containment of HLW at all times and to identify potential sources of escape or release into the environment.

tank farm

An installation of interconnected underground tanks for the storage of high-level radioactive liquid wastes.

tertiary age

First period of cenozoic era, thought to be between 65 and 2 million years ago.

thermal pollution

Degradation of water quality by introduction of a heated effluent.

threshold dose

The minimum dose of a given substance to produce a measurable environmental factor.

tolerance

The relative capability of an organism to endure an unfavorable environmental factor.

topography

The configuration of a surface area including its relief or relative elevations and the position of its natural and man-made features.

toxicity

The quality or degree of being poisonous or harmful to plant or animal life.

tracer injection detection tests

Injection of dye in water to trace water flow.

transmissivity

The rate at which water of prevailing kinematic viscosity is transmitted through a unit width under a unit hydraulic gradient.

transuranic waste

Solid radioactive waste containing primarily alpha emitters.

transuranium elements

Elements above uranium in the periodic table. All 13 known transuranic elements are radioactive and are produced artificially.

triassic period

First period of the mesozoic era. Thought to be between 225 and 190 million years ago.

tritium (^3H)

A radioactive isotope of hydrogen, a weak beta emitter with a half-life of 12.5 years.

TSP

Total suspended particulates. Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

turbidity

Measure of sediment or suspended foreign particle concentration in solution.

unconsolidated

Loosely arranged or unstratified sediment.

unincorporated places

Closely settled population centers without corporate limits.

USGS

United States Geological Survey.

vacancy rate

The ratio between the number of vacant housing units and the total number of units in a specified area.

vault

A reinforced concrete structure for storing canisters of immobilized high-level radioactive waste.

venting

Release of gases or vapors under pressure to the atmosphere.

washout

The removal of a pollutant from the atmosphere by precipitation.

waste heat

Heat in materials at temperatures that are close to that of ambient and hence not valuable for production of power. Waste heat must be discharged to the environment.

waste, radioactive

Materials from nuclear operations that are radioactive or are contaminated with radioactive materials and for which there is no practical use or for which recovery is impractical.

water pollution

Presence of one or more contaminants in such degree as to be detrimental to the intended use of the water.

water quality standard and criteria

Levels of pollutants according to the water use classification: drinking water, recreation use, propagation of fish and aquatic life, and agricultural and industrial use.

watershed

The area drained by a given stream.

water table

The upper surface of the groundwater.

weekly travelers

Workers who live near the work site during the week and travel home only on weekends.

zoning ordinances

Local ordinances dividing a city, town, or unincorporated place into zones governing land use and the size, shape, and use of structures within each zone.

zooplankton

Planktonic (floating) animals that supply food for fish.

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